POWER

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EVERY little while some "earnest friend of labor" or a cream-colored newspaper emits a howl that the heel of Capital is on the neck of the mechanic, and a few employers will whine that the unreasonable and work-shirking employee is getting all the profits and the boss will have to sell one of his six automobiles or go in arrears on his alimony to keep the wolf from the door.

Of course these are the opinions of pessimists and should be considered as such.

The successful business man knows that highly trained commercial skill is necessary to his success, and the mechanic is beginning to realize that his skill is a large factor in his employer's success.

They must both pull in the one direction if their efforts are to count for much.

Because of competition the business man has to be aggressive, and the same line of reasoning holds in the engine room.

Too many engineers lack confidence in their ability to do things !

When the old man engages an engineer to run his plant he says in effect:

"You are supposed to know your business. I won't be satisfied with your just keeping things a-goin', I want results. I want economy, efficiency and output.

"You save my money and I'll increase your wages. I'm hiring your *brains* as well as your brawn; now set 'em at work. I'll meet you half way."

It pays to be aggressive these days, when you can back it up with a sound, practical knowledge of your vocation.

Many an otherwise competent engineer has been kept back because he lacked confidence—because he was afraid to open his mouth after he had a strangle-hold on a good idea and then let go before both shoulders were on the mat

The engineer must "advertise his wares" and let the quality of his work do the rest.

A business man with a salable article does not stow it away on the top shelf of his shop and wait for a customer to suggest that it might be of use if it were brought into view.

He *advertises* it, makes it known. And, what is of most consequence, he sells it at a profit.

Treat your vocation as a business and ask yourself if your "salable article" is poked away on the top shelf of your brain. If so, pull it down, weigh it up; then if you find it is practical and profitable, let the old man know about it. Ten to one your idea will go through and you will have gained just that much prestige in the eyes of the boss.

Your Uncle Sam has a large and growing family, and the "boys" who are going to reflect credit on the old man's "bringin' up" are the ones who are equipping themselves with a good working knowledge of their vocation.

"You can't keep a good man down!" said Jonah as he wrenched himself from the belly of the whale.

And the whale doubtless agreed with Jonah even if Jonah disagreed with the whale.

Modern English Power Plant

A description of the 23,000-kilowatt plant recently completed at Dunston for the Newcastle-on-Tyne Electrical Supply Company. One of the turbines of this plant holds the record for low steam consumption.

In the April 18 issue were given the results of some record-breaking tests upon one of the turbines of the Dunston power station of the Newcastle-on-Tyne Electrical Supply Company, the best performance being a steam consumption of 11.8 pounds per kilowatt-hour.

In view of these results we believe a description of this new and thoroughly uptodate plant will be of interest to our readers, for much of which information we are indebted to our contemporary, *Engineering*.

The present rated capacity of the plant is 23,000 kilowatts, space being provided for an additional unit of 7000 kilowatts. As shown in Figs. 1 and 2, there are three distinct buildings, the coal-storage pocket, the boiler house and the engine room, the boiler house being situated between the other two. In addition there is the switch house, an independent structure located at some distance from the main group. The buildings are of steel framing sheathed with corrugated iron, very little brick being used in the construction.

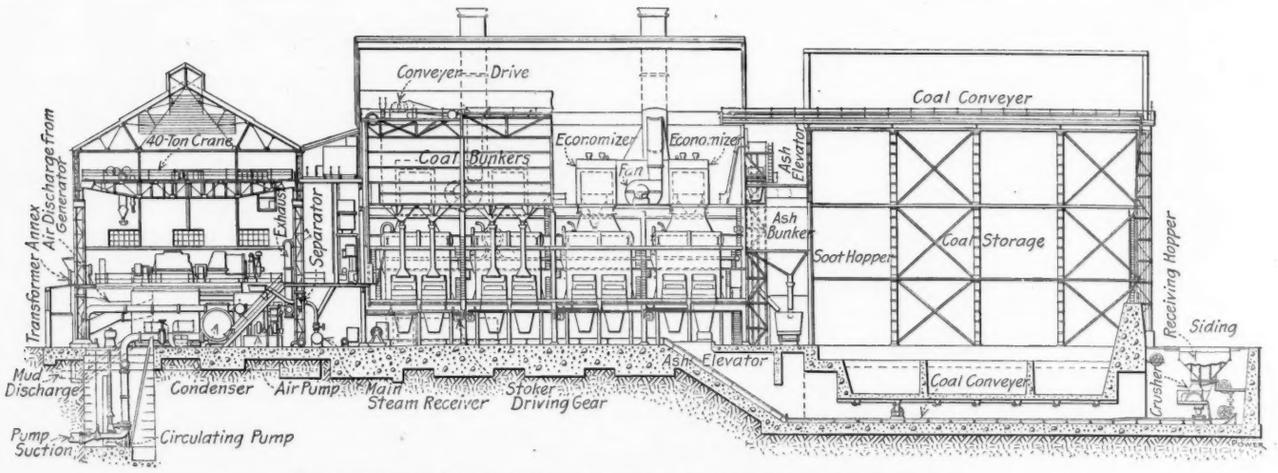


FIG. 1. LONGITUDINAL SECTION THROUGH DUNSTON POWER STATION

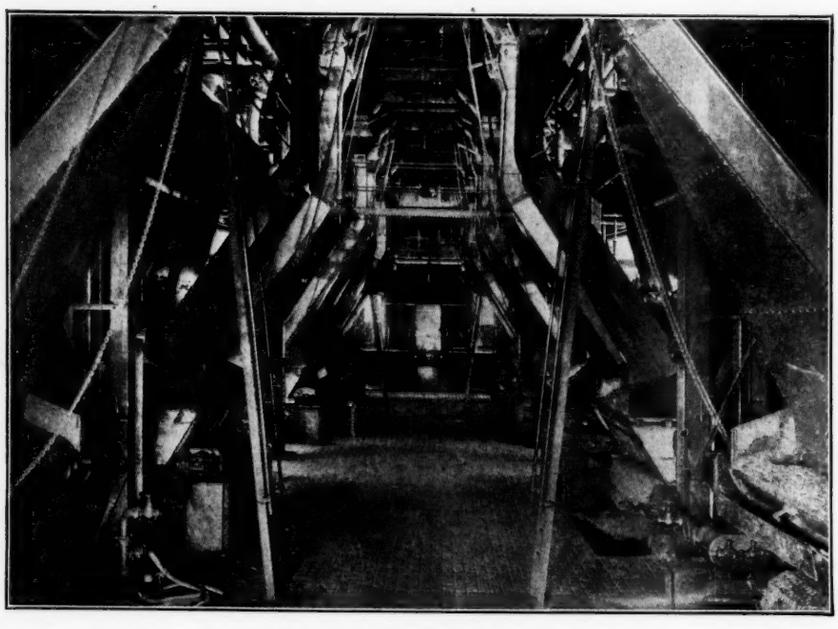


FIG. 2. BOILER-ROOM AISLE

BOILER HOUSE

The ultimate plans call for two boiler houses and two coal-storage pockets, one boiler house and its corresponding storage pocket supplying two turbine units. At present, however, there is but one boiler house and one storage pocket which supplies the three turbine units now installed.

The equipment consists of eight Babcock & Wilcox marine type of boilers set in batteries of two. Each battery is served by a chimney, an induced-draft fan and two economizers. There is one main steam pipe, feed-water pipe, hotwell, feed pump and ash conveyer for each set of four boilers.

The boilers are fed by chain-grate stokers and are provided with superheaters, each battery of two boilers being capable of furnishing, under normal conditions, 60,000 pounds of steam at a pressure of 200 pounds gage and a temperature of 572 degrees Fahrenheit. Fig. 2 is a view looking down the aisle between the rows of boilers.

COAL AND ASH HANDLING

Coal is dumped from cars to a receiving hopper (see Fig. 1), through a crusher and screen into an automatic filler. This discharges onto a continuous conveyer which runs over the storage pockets, over the bunkers located above the boilers, and down at the far end of the boiler room, then back under the boilers and storage bins. Thus coal may be discharged from the cars direct to the storage bins, direct to the bunkers over the boilers or from the storage bins to the boiler bunkers. This conveyer is capable of handling 40 tons of coal per hour.

The ash-handling equipment is dis-

tinct from the coal-handling plant, and consists of hand-propelled dump cars running on tracks below the boilers and receiving the ashes direct from the boiler ash hoppers. These tracks lead to a hoist which lifts the cars to a suitable hight to permit their contents being dumped into an ash bunker, located between the boiler room and the coal pocket. This ash bunker, in turn, discharges into gondola cars which carry the ashes away from the plant.

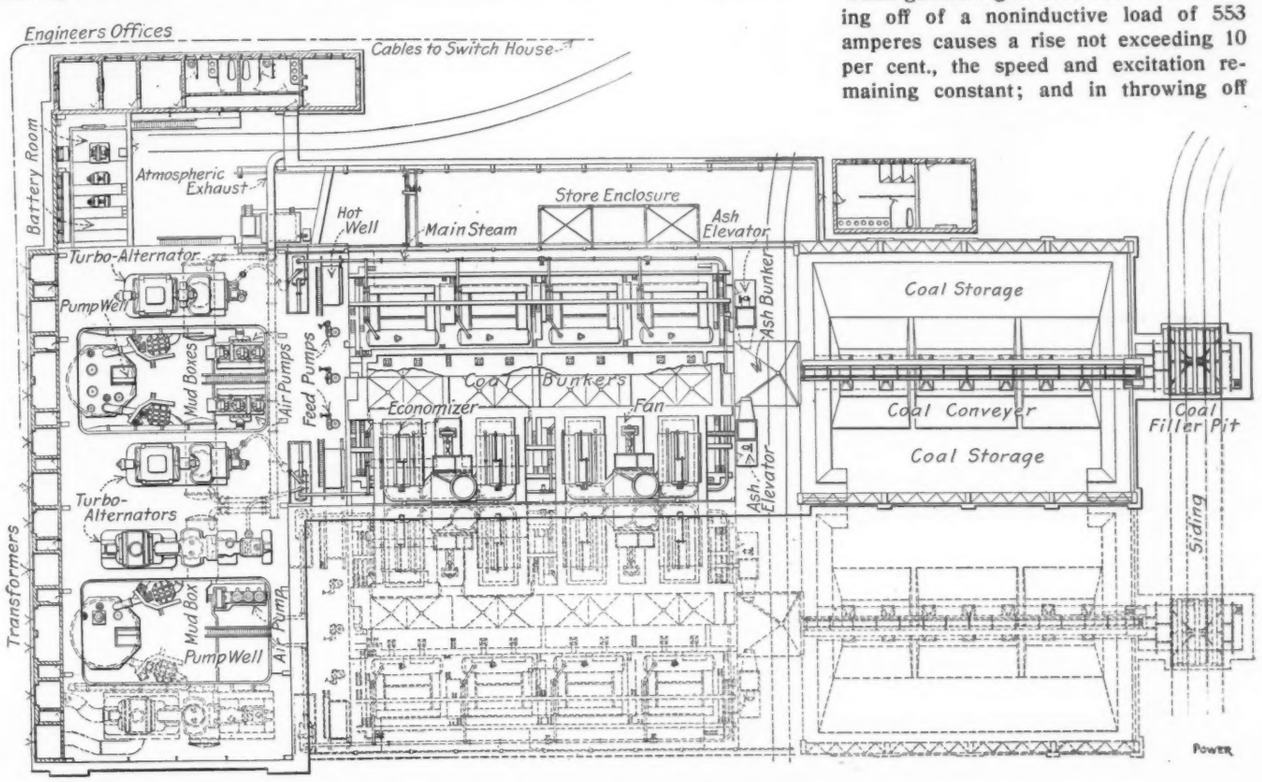


FIG. 3. PLAN OF GENERATING STATION

STEAM PIPING

From each of the two rows of boilers a steam main leads to its own receiver on the turbine-room floor, and from the receiver, pipes run to the steam separator, thence to the turbine stop valves. The two steam receivers are connected beneath the floor by a U-bend.

The steam pipes are of solid drawn mild steel with forged-steel flanges, pipes of 7 inches and greater having their flanges riveted; the smaller pipes have screwed flanges.

The feed piping is in the form of a complete ring divided by means of isolating valves into separate sections for each boiler; hence each economizer can be fed from either of two adjacent sections, or each boiler can be fed direct from the main when the economizer is cut out of service.

The feed pumps are located in the engine room and are thus removed from the dirt of the boiler room.

MAIN GENERATING UNITS

These consist of two 8000-kilowatt Allgemeine Elektricitäts Gesellschaft turbo-generators and one 7000-kilowatt Brown, Boveri & Co. Parsons type of turbo-generator. Each machine produces three-phase currents at 40 cycles and approximately 5750 volts. In each case excitation is furnished at 220 volts by exciters direct connected to the turbine shaft.

The voltage regulation of the Brown, Boveri & Co. machine is, as follows: When generating at 5750 volts the throwing off of a noninductive load of 553 amperes causes a rise not exceeding 10 per cent., the speed and excitation remaining constant; and in throwing off a load of 628 amperes with a power factor of 0.9 the rise in voltage does not exceed 20 per cent. The exciting circuit is so arranged as to allow the generator voltage to be raised from 5000

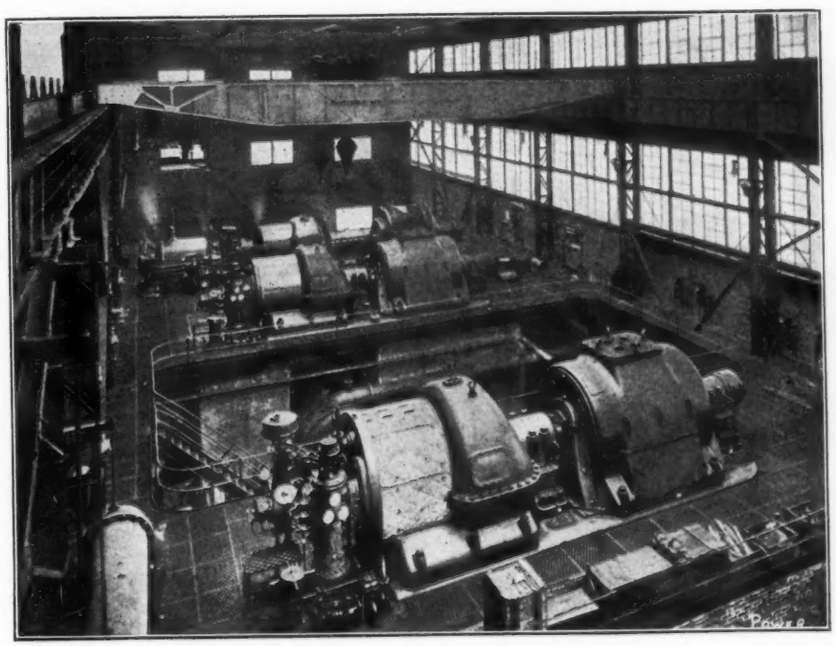


FIG. 4. TURBINE ROOM

volts at no load to 5750 volts at a load of 7000 kilowatts. This is the machine which showed the remarkable economy heretofore referred to.

The turbine governors of the Allgemeine Elektricitäts Gesellschaft machines are arranged so that the speed may be varied 5 per cent. above or below normal. A safety governor on each machine cuts off steam when the speed exceeds 1320 revolutions per minute.

Surface condensers are employed, capable of condensing 80,000 pounds of steam per hour while maintaining a vacuum of nearly 29 inches. The circulating pumps are located in pits below the level of the river and are driven through vertical shafts by three-phase motors mounted on the engine-room floor. These pumps will deliver 450,000 gallons of condensing water per hour.

The air pumps are of the three-throw Edwards type driven by three-phase motors.

A general view of the engine room is shown in Fig. 4.

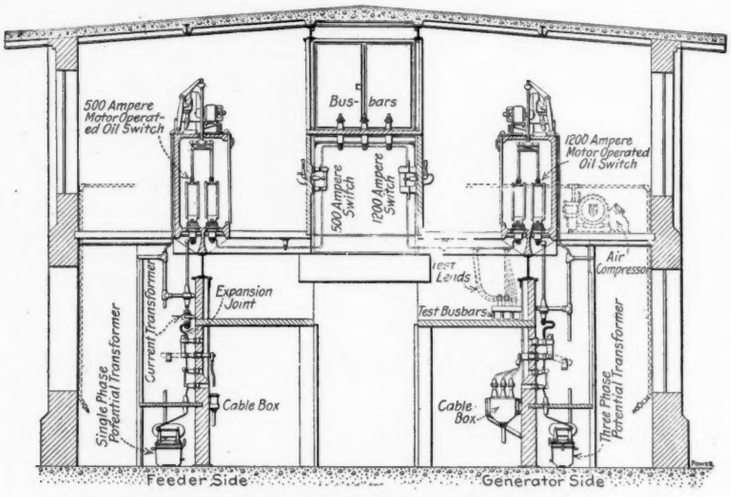


FIG. 5. SECTION THROUGH SWITCH HOUSE

ELECTRICAL EQUIPMENT

All the high-tension switching equipment is contained in a separate building, the only high-tension switches in the engine-room being an emergency gear near each generator for tripping the main generator switches, with which is also interlocked a field switch.

The switch house is a 135x33-foot two-story building. The control room, containing the operating boards, is on the first floor as are also the disconnecting switches, potential transformers, etc. The main oil switches and busbars are on the second floor. A section through the switch compartment is shown in Fig. 5.

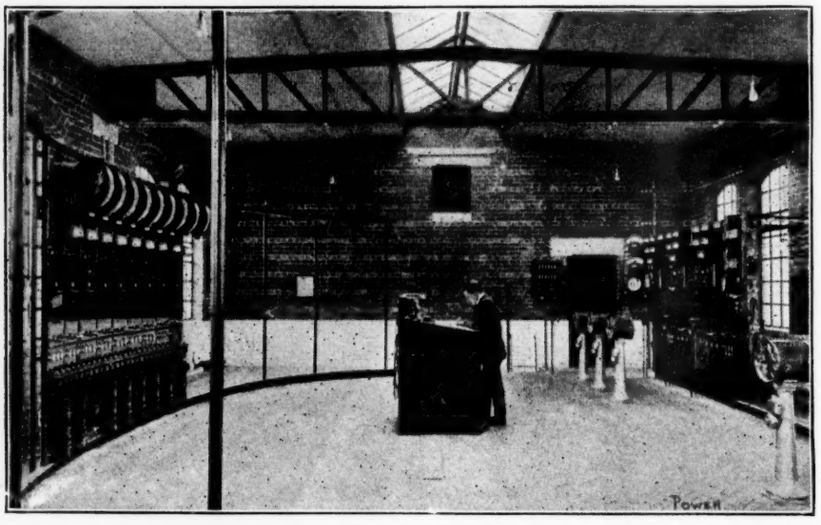


FIG. 6. CONTROL ROOM

The control gear is operated by direct current at 100 volts supplied by two storage batteries. A view of the control room is given in Fig. 6.

The direct-current switchboard, consisting of a 100-volt power and lighting panel and 500-volt traction panels, is located in one corner of the engine room.

Cost of a Power House

BY A. E. DIXON

Following is the building cost for a plant of 1600 kilowatts capacity which was constructed not long ago in one of the Middle Western States:

BUILDING-COST FIGURES

		Per Kilowatt	Per Square Foot
Steel work, roof trusses, beams, etc.	$4,959.40	$3.10	$0.30
Masonry, miscellaneous, etc.	19,813.26	12.39	1.20
Labor for construction	12,863.17	8.04	0.78
Lighting, wiring and material	948.18	0.593	0.058
Labor, erecting lighting material, etc.	234.21	0.146	0.014
	$38,818.21	$24.469	$2.352

The building to which the foregoing costs apply covered an area of 16,500 square feet and was originally designed to contain four 400-kilowatt direct-current generators direct connected to Corliss engines. The boiler room was laid out originally for eight 325-horsepower boilers but afterward the size of the boilers was changed and 400-horsepower units were used in the first battery installed. The engine room was spanned by a 20-ton crane. The original engine and generator installation was one unit of 400 kilowatts capacity; and later a 750-kilowatt horizontal turbine was installed.

The plant was designed by a firm of well known consulting and contracting engineers and the cost per square foot of area covered is not at all high. However, it might be considered that a very long look into the future was taken in providing space for extension to 1600 kilowatts capacity. The space allowed in this plant was extremely liberal, 10.3 square feet per kilowatt, and does not compare very favorably with plants of approximately the same size having from 4 to 5 square feet per kilowatt without undue crowding of the apparatus.

This particular plant was favorably located on good, sandy soil, close to a permanent water supply. Excavation was cheap and the other local conditions were favorable. In many cases the foundations below the ground line have cost from 25 to 35 per cent. of the total cost of the structure. Where foundations are very expensive they may sometimes run as high as 50 per cent. of the cost; this, however, is an extreme condition and rarely occurs where there is any choice in the location of a site for the plant.

In many of the larger steam plants the cost of the building per square foot is much higher than the figure for this plant, ranging from $5 to $10 without foundations, the higher costs applying to those plants having overhead coal bunkers or double-decked boiler rooms.

The Design of Steam Power Plants

By William F. Fischer

In this instalment the adaptability of the steam turbine for various classes of service is considered and its chief characteristics are noted.

Steam Turbines

When deciding between a reciprocating engine and a steam turbine the fact should not be overlooked that each possesses certain advantages over the other for a given service; hence the service for which the prime mover is intended, and the conditions of operation, should be carefully considered.

In large central stations the adoption of steam turbines effects a saving in the cost of the building, besides requiring lighter and smaller foundations than engines of the reciprocating type; this saving often amounting to from 10 to 15 per cent. of the total cost of the building. Also, with the advent of the steam turbine a new arrangement of power plant has sprung into existence in which the turbines are located on a floor above the boiler room, the station of the Fort Wayne and Wabash Valley Traction Company at Fort Wayne, Ind., being a good example of what has been done in this line.

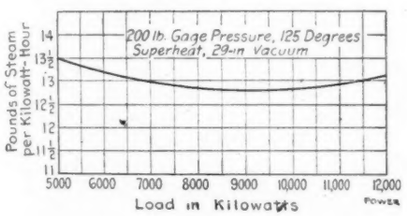


FIG. 1

Lubrication

Another point in favor of the steam turbine is that it requires no internal lubrication as the only rubbing surfaces to be lubricated are the main bearings. Therefore, oil does not come in contact with the steam and the condensation may be used over again for boiler-feed purposes without the necessity of separators, etc. This results in a saving in feed water and the expense incurred in cleaning heaters and boilers.

Besides the lubrication of the guide bearings, steam turbines of the vertical type require oil or water under a pressure of several hundred pounds per square inch in the step bearings, to balance the weight of the revolving element. This requires a high-pressure pump and extra-heavy piping.

Saving in Floor Space

It is claimed that the vertical-shaft turbine occupies only about one-tenth as much floor space per horsepower as a reciprocating engine of the same output, but in this respect the floor space occupied by the condenser, air pump, hotwell pump, circulating pump, etc., should be taken into account as they frequently occupy more floor space than the turbine itself. The necessary clearance around each of the auxiliaries should also be considered.

Following is a comparison of the amount of floor space occupied by several prime movers of approximately 2000 electrical horsepower, normal rating.

	Square Foot per Horsepower
Horizontal cross-compound Corliss engines	0.64
Vertical cross-compound Corliss engines	0.36
Westinghouse-Parsons steam turbines	0.146
Curtis horizontal steam turbines	0.098

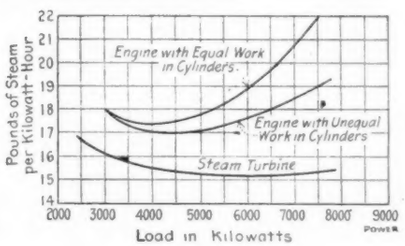


FIG. 2

The approximate floor space per electrical horsepower for large units is:

	Square Foot per Horsepower
Horizontal vertical cross-compound Corliss engines, Manhattan type, 5000 to 8000 horsepower	0.48
Vertical three-cylinder compound Corliss engines, 5000 to 8000 horsepower	0.2
Westinghouse-Parsons steam turbines, 5000 to 8000 horsepower	0.1
Curtis horizontal steam turbines, 5000 to 8000 horsepower	0.06
Curtis vertical steam turbines, 5000 to 8000 horsepower	0.04

The foregoing are based on the overall dimensions of the generating units and do not include condensers or auxiliaries.

Economy of Reciprocating Engines and Steam Turbines

Many stations handle a variable load; hence high economy at all loads is a very desirable feature. One of the principal claims of the steam-turbine builders is its relatively high steam economy at other than rated loads, whereas in the best-designed reciprocating engines the best all-round economy is obtained at one point only, the cutoff occurring either too early or too late at other loads, for the cylinder proportions.

Fig. 1 shows the results of a test on a 9000-kilowatt five-stage Curtis turbo-generator running at 750 revolutions per minute and at a steam pressure of 200 pounds gage, with 125 degrees superheat and a 29-inch vacuum. The load curve is almost flat and shows a high economy at all loads from 6000 to 12,000 kilowatts; at loads below 5000 kilowatts the economy falls off rapidly.

Fig. 2 illustrates the economy of a 5000-kilowatt Curtis turbine as compared with a 5000-kilowatt four-cylinder compound engine. Both machines were operated under similar conditions with a steam pressure of 175 pounds gage and saturated steam.

The extreme overload capacity in favor of the steam turbine is an important factor in central-station service where there is apt to be one or more sharp peak loads of short duration, such as frequently occurs during a thunder shower.

Vacuum, Steam Pressure and Superheat

While it is not absolutely necessary

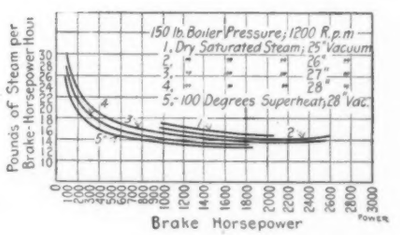

150 lb. Boiler Pressure; 1200 R.p.m.
1. Dry Saturated Steam; 25" Vacuum
2. " " " 26" "
3. " " " 27" "
4. " " " 28" "
5. 100 Degrees Superheat, 28" Vac.
Pounds of Steam per Brake-Horsepower Hour
Brake Horsepower
POWER

FIG. 3

to use a high vacuum with a steam turbine, it is desirable to do so to obtain advantage of the higher economy made possible thereby. Steam turbines can use a high vacuum to much better advantage than the reciprocating engine, and show a much greater increase in economy.

As a rule, any increase in vacuum above 26 inches adds but little to the economy of the reciprocating engine, as it is not adapted to handle the large volumes of steam due to the lower pressure and the increased cylinder condensation caused by the low-pressure steam would offset any gain resulting from the additional expansion.

Fig. 3 gives the economy of a 1250-kilowatt Westinghouse-Parsons turbine in terms of pounds of steam per brake horsepower-hour, operating with a vacuum of from 25 to 28 inches.

The gain in economy by operating a steam turbine at a vacuum higher than 28 inches does not usually warrant the expenditure of the additional money necessary for the better class of condensers, pumps, etc., required to produce higher vacuum.

The steam pressure usually carried on steam turbines varies from 150 to 200 pounds gage, and the steam is usually

superheated from 100 to 200 degrees Fahrenheit above the temperature corresponding to its pressure. As far as the total overall station economy is concerned, there is not much to be gained by increasing the pressure or superheat above the figures given.

The construction of the steam turbine permits the use of highly superheated steam as the turbine requires no internal lubrication and there are no internal rubbing or wearing surfaces, whereas the difficulties experienced with lubrication and the destruction of valves, glands, etc., under high temperature limits the use of superheated steam with all engines of the piston type.

Fig. 4 shows the water rate of a 1500-kilowatt four-stage Curtis turbine operating at 150 pounds gage pressure with a 28-inch vacuum. The upper curve shows the steam consumption in pounds per kilowatt-hour operating with dry steam, and the lower curve the steam consumption with the steam superheated 125 degrees. The saving is due both to the maintenance of drier steam at the

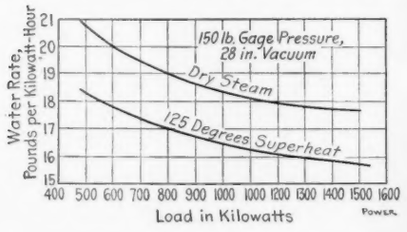


FIG. 4

throttle and to a reduction in friction upon the blades caused by condensation as the steam expands.

Steam turbines as well as reciprocating engines should be protected by steam separators placed in the steam line near the throttle. These should be of sufficient capacity to retain all water carried over by the steam, for entrained moisture in the steam increases the water rate to a large extent besides causing excessive wear on the turbine blades.

TURBO-GENERATORS AND THEIR REGULATION

Since the introduction of the steam turbine the general characteristics of electric-generating apparatus have been modified to a large extent and rotative speeds have been increased. This has resulted in minimum bulk and less cost of construction so far as is consistent with strength and durability. A 5000-kilowatt 40-pole engine-driven generator running at 75 revolutions per minute is about 40 feet in diameter and weighs approximately 980,000 pounds, whereas a 5000-kilowatt 4-pole turbine-driven generator running at 750 revolutions per minute is about 12 feet 6 inches in diameter and weighs approximately 234,000 pounds; both machines being 25-cycle units with the weights of shafts and journals included in each case.

The preferable construction for alternating-current generators comprises a rotating field and stationary armature. A uniform driving torque is desirable and this is more easily obtained in steam turbines than in reciprocating engines because the forces acting upon the blades of the turbine are continuous and the speed of the rotor is uniform, whereas the variable pressure acting upon the crank pin of a reciprocating engine makes necessary the use of heavy flywheels.

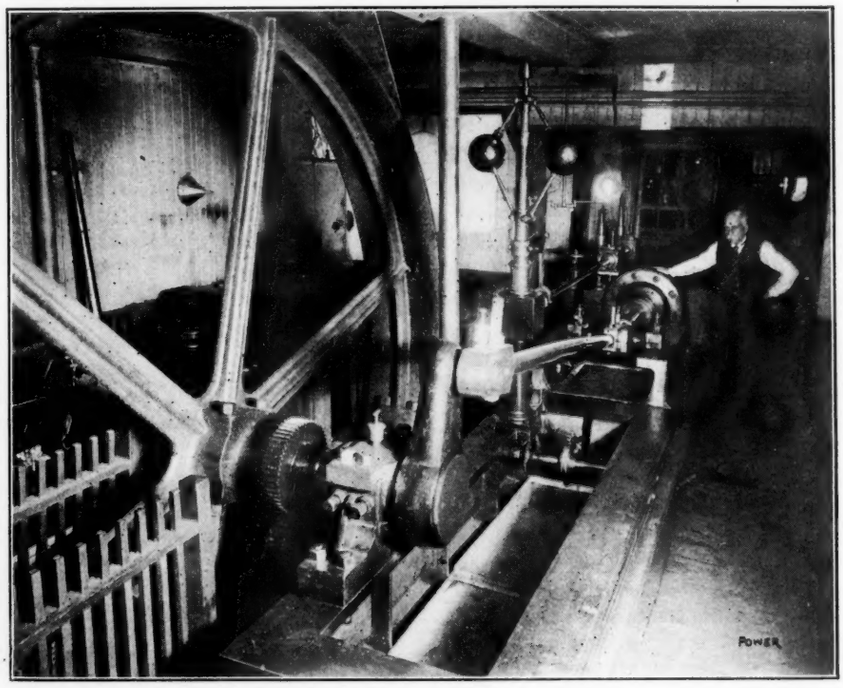
Published tests of Parsons and Curtis steam turbines show an average fluctuation of 2 per cent. from no load to full load, and 3 per cent. from no load to 100 per cent. overload. Turbine-driven alternating-current generators may be operated satisfactorily in parallel with those driven by reciprocating engines, providing the engine possesses good regulation. The following is from a paper entitled "Power Plant Economics," by H. G. Stott, and will serve to illustrate this point:

"In one of the plants of the Interborough Rapid Transit Company, of New York City, a steam turbine was thrown in parallel with a double-compound engine carrying a railway load. The elementary overloads were carried almost entirely by the steam turbine, while the engine load remained practically constant, showing the ability of the steam turbine to respond quickly to overloads under the most exacting conditions of service. In this case the action of the steam turbine was much like that of a storage battery."

Veteran Engineer and Engine

It has been written that threescore years and ten is the span of mortal life. What the normal span of life for an engine is no authority has yet laid down, but certain it is that the engine in this story has surpassed in number of years of useful work a great majority of the engines ever built.

This engine was put into service in December, 1855, and with the exception of eight and one-half days during which repairs were being made on it, has been in continuous operation ever since in the plant of the Case Lockwood & Brainard Company, of Hartford, Conn. The engine was built by the Woodruff-Beach Company of the same city.



MR. LYNCH AND THE ANCIENT ENGINE

The only repairs that ever were made to the engine were a new crank disk and a new cylinder which were put in during 1906. The original crank-pin brasses were in use for 41 years.

The engine has some of the earmarks of the old timers, with its box bed and plain crank. At the time it was built it was the only design of engine having an automatic-cutoff quick-closing type of steam valve with the exception of the Corliss. The valve gear is of the well known Woodruff & Beach design, poppet inlet and slide-valve exhaust. The diameter of the cylinder is 18 inches and the stroke is 36 inches; the steam pressure is 85 pounds, gage, and the engine runs at 55 revolutions per minute.

Mr. C. H. Lynch, the present chief engineer, took charge of the engine in 1865, after he returned from serving with the Union forces in the Civil War.

A New High Pressure Gas Blower Set

Recent practice in gas works is to increase the generator capacity by increasing the air-blast pressure. This article describes a turbo-blower set designed to meet the increascreased pressure requirements and gives the results of steam consumption and speed-regulation tests.

Among the radical modifications being introduced into the modern gas works is the raising of the blast pressure about 100 per cent.

In the majority of existing plants the blowers are operated at a pressure varying from 20 to 22 inches, but the blower sets now being installed in the new plants of the Brooklyn Union Gas Company, and the Consolidated Gas Company of New York, are designed for 40-inch pressure.

The object of this change is to materially reduce the "blowing period," and thereby increase the number of "making periods" per 24 hours with the ultimate result of increasing the capacity of a given machine. It is estimated that this increase will not be less than 25 per cent., and it is anticipated that it will be nearer 50 per cent. A pressure of 40 inches of water, or nearly 1½ pounds per square inch, is quite a new departure in gas-blower design.

The turbo-blower unit shown in the accompanying figure consists of a single-stage turbine direct connected through a flexible coupling to a multivane type blower, the two machines being mounted on a common cast-iron bedplate. The turbine is of the single-stage Terry type. The steam is expanded in one step from initial pressure down to exhaust pressure, thus avoiding the complication of any intermediate diaphragms and their stuffing boxes, and the main casing is subjected to exhaust pressure only.

The glands or stuffing boxes are of the floating bushing type, kept steam tight by ground metal joints, eliminating the necessity of any soft packing.

The speed-regulating governor is mounted directly on the outboard end of the turbine shaft, and no possible failure of any intermediate gear drive can occur. Running at turbine speed, the governor is naturally very powerful and at the same time highly sensitive, as will be shown by the results of the regulation tests quoted later.

The two machines are connected through a flanged coupling, the pins of which are fitted with sliding sleeves; thus the thrust of each machine is taken care of independently, and the end play of either machine is not transmitted to the other. Rubber bushings are fitted to the outside of these sleeves, allowing smooth running with a certain amount of misalinement of the two machines.

The blower is of the Sturtevant double-inlet multivane type and is constructed of steel throughout. The blades are mounted on a solid central disk carried by the hub, and the outer ends of the blades are supported by heavy rings.

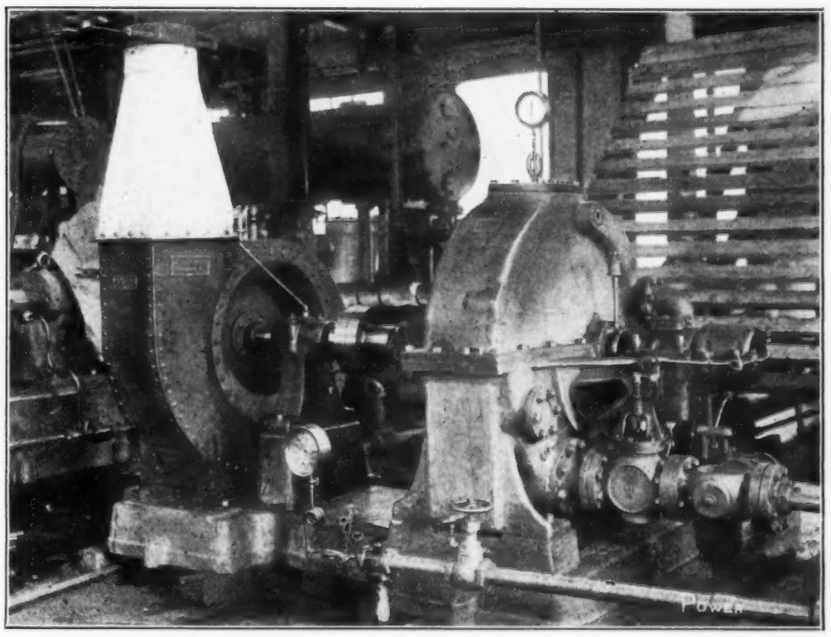
The bearings of both machines are of the self-alining, ring-oiling type. As the rotors of both turbine and blower comprise but a single wheel in each case, the construction can be made very light, while maintaining ample strength and rigidity for the speeds employed. This factor, together with the use of liberal bearing surfaces, eliminates the necessity of any special forced oiling system and its attendant complications.

Being a new design, these machines were subjected to a series of exhaustive tests at the makers' works, and final acceptance tests were carried out under conditions approximating as nearly as possible the gas-works practice. To obtain this a special cone was constructed and fitted to the outlet of the blower. A sliding gate valve on the end of this cone could be opened and closed quickly to throw the load on and off the blower almost instantaneously, thereby testing the governing properties of the turbine and the actual behavior of the whole machine under service conditions.

The guarantees called for in the contract stated that the turbines were to develop 200 brake-horsepower when operating with a steam pressure of 125 pounds at the throttle and a back pressure varying from zero to 5 pounds. The steam consumption guarantee was 38 pounds per brake horsepower with atmospheric exhaust and 42 pounds per brake horsepower with 5 pounds back pressure. The quantity of air to be delivered by the blower was 14,000 cubic feet per minute against a pressure of 40 inches.

The turbines are arranged for 5 pounds back pressure in order that the exhaust from the turbine may be discharged directly to the gas machine; a system which, although naturally impairing the efficiency of the turbine to a certain extent, shows a distinct gain in overall efficiency over the old system of utilizing live steam in the generator. In addition to being more efficient, this arrangement is obviously more convenient.

Tests, the results of which are given in the accompanying table, were conducted by Mr. Stiles, superintending engineer of the Brooklyn Union Gas Company, and Mr. Wepfer, of the same company. The full log of the readings



TURBINE-DRIVEN HIGH-PRESSURE GAS BLOWER

taken is given, and an examination of this will show that both the turbine and the blower have beaten their guarantees by a large margin.

The method of testing was as follows: Pressure, temperature and calorimeter measurements were taken just before the governor valve and the exhaust pressure was measured in the exhaust pipe just beyond the outlet of the turbine. The exhaust steam was taken to a surface condenser, and the discharge water from the hotwell was weighed. Condenser leakage tests were made before and after the turbine tests and they showed that the leakage was negligible. The condenser was vented at the top so that no vacuum was produced at the exhaust of the turbine. The air was measured by placing a long cone on the discharge of the blower; the cone was calibrated, and found to have a coefficient of discharge of 0.94. The pressure was taken by means of a mercury U-tube placed directly at the outlet of this cone. According to the guarantees in the contract the total steam required to deliver 14,000 cubic feet of air per minute at 40 inches of pressure was to be not more than 7600 pounds per hour, when the turbine was working under atmospheric exhaust conditions.

The actual air horsepower delivered during the test was 112.6, and the dry steam consumption was 6587 pounds per hour, so that the blower was delivering 27.5 per cent. more work than was called for, with a steam consumption 13.35 per cent. less than the guaranteed maximum. Reducing the guarantee conditions to steam consumption per air horsepower, the guarantee calls for 86.13 pounds maximum steam consumption per air horsepower, whereas the tests show 58.5, or an overall Rankine cycle efficiency of 25.2 per cent.

The speed regulation tests showed a speed variation as follows:

No blower load, 2490 revolutions per minute.
Full load, thrown on momentarily, 2400 revolutions per minute.
Full load, settled, 2460 revolutions per minute.

Thus it will be seen there was a momentary speed drop of 3.6 per cent. and a settled drop of only 1.2 per cent.

With the full load on the blower and the gate suddenly closed, the following results were obtained:

Full load, 2460 revolutions per minute.
No blower load, momentary, 2575 revolutions per minute.
No blower load, settled, 2490 revolutions per minute.

This shows a momentary jump of 4.7 per cent. and a settled increase of 1.22 per cent.

It has been pointed out that a big saving is anticipated in the gas-machine end by the adoption of this new blower, but it should be further pointed out that the saving in economy in the blower itself is quite a factor. In some tests on a 22-inch blower made recently under substantially the same conditions and with the same type of blower the overall water rate was 76.2 per cent. per air horsepower as against 58.5 now obtained. In other words, the new blower sets show an efficiency 16.7 better than those now universally used in this country.

RESULTS OF STEAM CONSUMPTION TEST

Time	Steam pressure at throttle, pounds per sq.in.	Pressure at nozzle inlets, pounds per sq.in.	Superheat, degrees F.	Quality as shown by calorimeter, per cent.	Back pressure	Water readings, gross weight, pounds	Water readings, tare, pounds	Water readings, net, pounds	Total water rate, pounds per hour	Total water rate corrected for sat. steam, pounds per hour	Speed, R.p.m.	Temperature of air at cone outlet, degrees F.	Density of air, pounds per cu.ft.	Velocity press. at cone outlet, inches mercury	Velocity, press. reduced to inches of water	Velocity at cone outlet, ft. per minute	Volume of air delivered, cu.ft. per min.	Air H.P., actual	Water rate, lbs. per air h.p. hour
2–10	140	103	17		0						2,480	114							
2–13						433	129	304	6,080	6,200									
2–15	131	103	26		0						2,470			3.5	47.6	27,000	15,220	114.1	
2–16						476.5	157	319.5	6,390	6,560									
2–19						481	137	344	6,880	7,000									
2–20	145	105	17		0						2,480			3.6	48.95	27,350	15,400	118.6	
2.22						495	159	336	6,720	6,840									
2–25	145	105	23		0	458	136	332	6,640	6,800	2,480			3.5	47.6	27,000	15,220	114.1	
2–28						490	159	331	6,620	6,780									
2–30	135	102	30		0						2,440	114		3.4	46.2	26,600	15,000	109.1	
2–31						451.5	135	316.5	6,330	6,525									
2–34						477	161	316	6,320	6,475									
2–35	150	106	24		0						2,480			3.8	51.7	28,100	15,850	129	
2–37						494	136	358	7,160	7,340									
2–40	148	101	25		0	478.5	157	321.5	6,430	6,600	2,450			3.4	46.2	26,600	15,000	109.1	
2–43						447.5	137	310.5	6,210	6,365									
2–45	148	100	22		0						2,445			3.4	46.2	26,600	15,000	109.1	
2–46						468	161	307	6,140	6,280									
2–49						454.5	135	319.5	6,390	6,520									
2–50	153	102	19		0						2,450			3.4	46.2	26,600	15,000	109.1	
2–52						480.5	160	320.5	6,410	6,530									
2–55	150	101	19		0	458	134	324	6,480	6,610	2,460	113		3.4	46.2	26,600	15,000	109.1	
2–58						470.5	161	309.5	6,190	6,310									
3–00	150	100	17		0						2,460			3.4	46.2	26,600	15,000	109.1	
3–01						438.5	132	306.5	6,130	6,240									
Average	145.	102.5	22	100	0				6,442	6,587	2,463	113.6	0.0694	3.48	47.3	26,900	15,169	112.6	58.5

Velocity from Heat Energy

In steam-turbine work it is necessary to calculate the velocity which would be acquired by the jet when the steam is expanded so as to convert a given number of heat units into work.

This may be done by multiplying the square root of the number of heat units available by 223.6.

For example: A pound of steam of 210 pounds absolute superheated 85 degrees, expanded to atmospheric pressure, would convert into work 205 B.t.u. and this work done upon the pound of steam would get it into velocity at the rate of 14.32x223.6=3202 feet per second, 14.32 being the square root of 205.

The reason for this is that

$$v = \sqrt{2gE}$$

where v = Velocity in feet per second,
$g = 32.16$ " " "
E = Energy in foot-pounds.

If the energy is given in heat units U, the mechanical energy will be

$$E = 777.52\ U,$$

so that

$$v = \sqrt{2 \times 32.16 \times 777.52}\sqrt{U}$$

or

$$v = 223.6287\sqrt{U}$$

The $E = \frac{Wv^2}{2g}$ formula was explained by Uncle Pegleg in POWER for May 17, 1910.

From all accounts alcohol has not been a success in Germany as an industrial fuel.

Steam Engines and Steam Turbines

By William Westerfield

A brief description of the operating conditions under which a comparative test of reciprocating-engine- and turbine-driven units was made, condensing and noncondensing.

There is so much interest shown in the discussions of the relative merits of the reciprocating steam engine and the steam turbine as prime movers that I feel that any positive information relating to the performances of either may be helpful in pointing out the merits of each and assist in determining where either is most likely to prove satisfactory.

In 1907 I had charge of a plant on the Pacific coast in which there were one 9 and 18 by 16-inch, two 16 and 32 by 22-inch tandem-compound condensing engines and one 300-kilowatt steam turbine. From the operating report for October of that year (see table), it will be noticed that the engines and turbine were operated part of the time condensing and part noncondensing.

OPERATING REPORT FOR THE MONTH ENDING OCTOBER 31, 1907

Day of Month	Kilowatt-hr. Totals	Total Oil, Gallons	Oil per Kilowatt-hr., Gallons	Unit Operated
1	2,424	1,437	0.59	Turbine, condensing
2	2,434	1,282	0.53	Turbine, condensing
3	2,160	1,282	0.59	Turbine, condensing
4	2,496	1,375	0.55	Turbine, condensing
5	2,784	1,531	0.54	Turbine, condensing
6	2,280	1,531	0.67	Turbine, condensing
7	2,184	1,313	0.60	Engine No. 1,* noncondensing
8	2,040	1,531	0.75	Engine No. 2,* noncondensing
9	2,184	1,594	0.73	Turbine, noncondensing
10	1,728	1,812	1.04	Turbine, noncondensing
11	2,184	1,468	0.67	Turbine, noncondensing
12	2,544	1,500	0.58	Engine No. 1, condensing
13	2,040	1,562	0.76	Turbine, condensing
14	2,664	1,313	0.49	Engine No. 1, condensing
15	2,592	1,437	0.59	Engine No. 1, condensing
16	2,784	1,531	0.55	Turbine, condensing
17	2,516	1,406	0.55	Turbine, condensing
18	2,808	1,468	0.52	Turbine, condensing
19	3,024	1,500	0.56	Engine No. 1, condensing
20	2,256	1,500	0.66	Engine No. 1, condensing
21	2,592	1,375	0.53	Engine No. 1, condensing
22	2,976	1,594	0.53	Engine No. 1, condensing
23	2,712	1,594	0.58	Engine No. 1, condensing
24	2,832	1,531	0.54	Engine No. 1, condensing
25	3,048	1,531	0.50	Turbine, condensing
26	3,048	1,812	0.59	Turbine condensing
27	2,208	1,375	0.62	Turbine, condensing
28	2,640	1,281	0.44	Turbine, condensing
29	2,616	1,468	0.56	Turbine, condensing
30	2,544	1,250	0.45	Turbine, condensing
31	2,688	1,312	0.42	Turbine, condensing
Total..	78,020	Average....	0.55	

*Engines Nos. 1 and 2 were 16 and 32 by 22-inch tandem compound.

Conditions then were not favorable for making an efficiency test but were good for making a comparative test. It will be noticed that in running condensing from the first to the sixth, inclusive, the turbine required from 0.53 to 0.67 gallon of fuel oil per kilowatt-hour output. On the seventh and eighth the engine used 0.60 and 0.75 gallon running noncondensing, while on the ninth, tenth and eleventh, the turbine, running under the same conditions, used 0.73, 1.04 and 0.67 gallons. On the thirteenth, the turbine running condensing required 0.76 gallon per kilowatt-hour while 0.66 gallon is the highest consumption shown by the engine. In running noncondensing the turbine required 1.04 gallons against 0.75 gallon as the highest required by the engine. The reverse of this performance may usually be expected; that is, the consumption per output is more uniform in the steam turbine than in the reciprocating engine under widely varying load conditions. This may be the case when the consumption of the prime mover alone is considered, but under the conditions in this plant the report covers the entire work, including all the auxiliaries.

Up to the twelfth with the steam turbine a vacuum of from 26 to 28 inches was maintained, which was not as favorable as is generally advocated. After this a new circulating pump was in action, and it will be noted that the results are better after this date, as a vacuum of from 27 to 28½ inches was maintained. The larger engines and the turbine were of approximately the same horsepower rating. The engines exhausted into condensers having 600 square feet of cooling surface each and the turbine into one having 1200. With the engine condensers there was used a combined air and circulating pump, while with the turbine condenser there were a centrifugal circulating pump, a motor-driven turbine hotwell pump and a dry-vacuum pump, the arrangement being substantially as shown in Fig. 1.

The engines did better than the turbine on the light loads as the work of the condensing apparatus could be varied as the load varied, it being only necessary to vary the speed of the combined pump so that it would maintain a suitable vacuum. In the case of the turbine condensing apparatus this was not possible because the centrifugal pump, like the turbine, is a one-speed machine, and its speed cannot be so readily varied as may the ordinary air and circulating pump, so that when the turbine was running on the light load the condensing apparatus was doing almost the same work as on the peak load.

The lowest consumption of fuel for the engine-driven units for the month was 0.49 gallon per kilowatt-hour with a vacuum of 22 inches on the peak load, and as the load became lighter the vacuum would increase to 26 inches. The lowest fuel consumption with the turbine was 0.42 gallon on the thirty-first. The fuel cost was 2 1/7 cents per gallon, or 0.88 cent per kilowatt-hour output. For the month the average fuel consumption was 0.55 gallon per kilowatt-hour; the cost per kilowatt-hour was 1.16 cents; the total cost per kilowatt-hour output, not including interest and depreciation, was 1 7/10 cents.

There were several drawbacks which made great economy impossible while I was in this plant, though they were remedied later on my recommendation. The pumps delivered water to the boilers through a closed feed-water heater which instead of being set below the hotwell was above it and had to lift the water with the result that when the load became heavy and the water of condensation quite hot, cold water makeup or waste was used to keep the temperature down.

Although I did not get the results I desired, I did succeed in reducing the cost per kilowatt from 3 cents per kilowatt-hour in July to 1 7/10 cents in October of the same year, and acquired a knowledge of many things I could not have learned in any other way, among them being that the steam turbine in which the flow of steam is horizontal will not stand water in any quantity. When I went to this plant the turbine had not been started, but was hooked up ready for steam. There was a 9 and 18 by 16-inch compound engine set near the turbine, and rather than run a new line the ell where the line dropped to the engine was taken off and a tee placed in its stead; from the top of this tee another ell gave an outlet to the turbine. There were separators in the steam pipes

to the engine and turbine, which were bled by hand, but no traps.

The piping system was poorly designed. From the header a 14-inch steam pipe led into the engine room, Fig. 2, and as the largest steam pipe to the engines was 8 inches, there was a depth of 3 inches in the large pipe below the lowest point of opening in the largest of the engine steam-pipe outlets. There were no drains from this large pipe, which had the habit of collecting water, and about the time things were going nicely on the peak load and the turbine had all it could handle, over would come a slug and the machine would slow down. The only thing to do to get out of the tangle was to get one of the engines in on the load as soon as possible. After a few experiences of this kind I refused to operate the turbine until the proper piping connections were made.

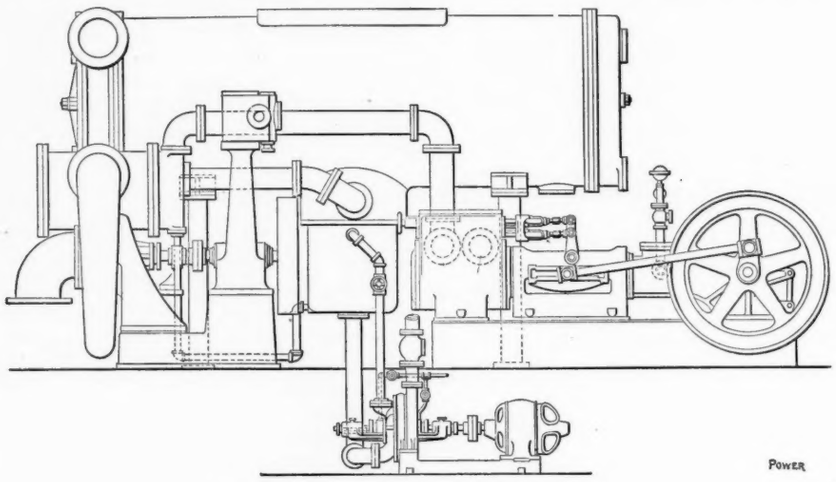


FIG. 1. ARRANGEMENT OF AUXILIARIES

The actual steam consumption of the prime mover per output may be very misleading, but it is the best index of the economy of the prime mover and that of its auxiliaries; the condensing apparatus and other appliances which are incident to its operation. It requires a greater amount of mechanical energy to maintain a vacuum of 28 to 29 inches than for 25 or 26 inches, and while the reciprocating engine will give its maximum economy with a vacuum of 25 or 26 inches, the turbine requires 28 to 29 inches.

There are at present about 173 miles of hydraulic power mains laid in London served by five central pumping stations from two to three miles apart. The supply is over 21,00,000 gallons per week, with 6787 machines and 221 fire hydrants connected. The number of machines in 1900 was 4137. The latest station is situated in Grosvenor road, Westminister, and has five engines, capable of pumping 28,000 gallons per hour each into the main at a pressure of 800 pounds per square inch.

Loss Due to Incomplete Combustion

The accompanying tables show in percentage and dollars the loss that occurs from incomplete combustion, which results in a low CO_2 percentage on every $1000 worth of coal burned. Table 1 shows the percentage of CO_2 ranging from 14 down to 3 per cent. and showing a loss of from 0 to 53½ per cent. and from no dollars to $535. This is based on 14 per cent. CO_2 as being the maximum under working conditions, and means that with 3 per cent. CO_2 there is a loss of 53½ per cent. of the heat units in the coal and $535 loss out of every $1000 expended in fuel.

TABLE 1. LOSS DUE TO INCOMPLETE COMBUSTION HAVING A LOW CO_2 ON EVERY $1000 WORTH OF COAL BURNED

Percentage CO_2	Loss, Per Cent.	Loss, Dollars
14	No Loss	...
13	1½	15
12	2½	25
11	4½	45
10	6	60
9	8½	85
8	11	110
7	15	150
6	19½	195
5	26½	265
4	32	320
3	53½	535

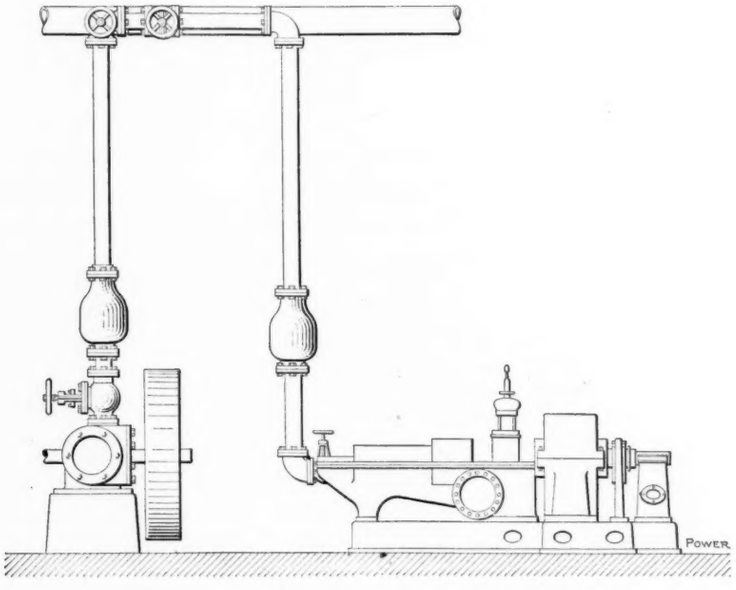


FIG. 2. TURBINE PIPE ARRANGEMENT

In Table 2 is shown the loss from a high stack temperature for every $1000 worth of coal burned. This table is based on an atmospheric temperature of 60 degrees, the coal containing 14,500 B.t.u. per pound of coal and of 18 pounds of air supplied per pound of coal consumed. The range in stack temperature is from 200 to 560 degrees Fahrenheit; the percentage of heat loss going up the stack ranges from 4.34 to 15.5 per cent. and there is a loss in dollars of from $43.40 to $155.

TABLE 2. LOSS OF HIGH TEMPERATURE IN STACK ON EVERY $1000 WORTH OF COAL BURNED

Stack Temp., Deg. Fahr.	Per Cent. of Heat Going Up Stack	Loss on Every $1000 Worth of Coal Burned	
200	4.34	$43.40	Temp. outside air, 60 degrees.
250	5.89	58.90	
300	7.44	74.40	
350	8.99	89.90	One pound coal = 14,500 B.t.u.
400	10.54	105.40	
450	12.09	120.90	
500	13.64	136.40	18 pounds of air per pound of coal.
560	15.50	155.00	

Both tables are worth noting and the wise engineer can get considerable food for thought in comparing them with the results obtained from his own plant. These figures were prepared by George H. Diman, consulting engineer.

Advantages of Superheated Steam

By H. J. Macintire

The effect of superheated steam on cylinder condensation; some results gained by the use of superheated steam and its limitations.

Thermodynamics teaches that little gain in work can be obtained by the use of superheated steam, yet experience shows that moderate superheat gives a decided advantage. The increase in work theoretically possible can best be shown by the temperature-entropy diagram. Referring to Fig. 1, the theoretical amount of work between the limits expressed in the diagram can be represented by the area *A B C D E F A*. The increase in the available work by the use of superheated steam over that which can be obtained with saturated steam is shown by the area *C D E F C*. Thus,

Area *ABCFA* ..... 264 B.t.u.
Area *ABCDEFA* ..... 282 B.t.u.
Area *CDEFC* = 282 — 264 = 18 B.t.u.
or 6.8 per cent. gain.

It is clear that if the only advantage in the use of superheated steam were this 6.8 per cent. gain, it would not pay to go to such pains and expense to use it. Fortunately, however, superheated steam will reduce cylinder condensation.

Consider a simple steam engine working between the temperature limits of 338 and 212 degrees Fahrenheit. At release and during exhaust the cylinder head, clearance space and that part of the barrel exposed to the steam will be cooled by the relatively cool exhaust steam. This cooling will vary with the clearance spaces, ratio of expansion, etc., but when the hotter admission steam enters it encounters this cooler metal and condensation takes place. As the steam condenses, more steam from the boiler comes in to take its place; hence at cutoff there is much more water and steam than is accounted for as steam by the indicator diagram.

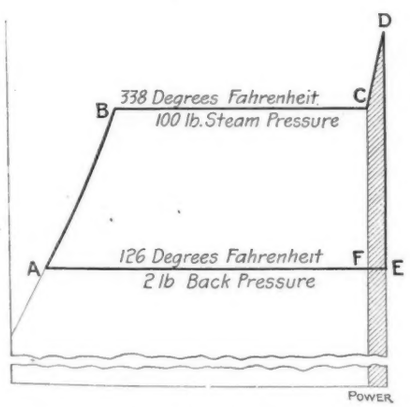


FIG. 1. GAIN DUE TO SUPERHEATED STEAM AS SHOWN BY THE TEMPERATURE-ENTROPY CHART

Referring to Fig. 2, the area *M N Q R* represents an ideal diagram using the theoretical amount of steam, but cylinder condensation increases the amount of steam entering the cylinder, and the actual amount of steam is represented by the line *M O*. The actual indicator diagram is shown cross-hatched, and the ratio of its area to the area *M O P R* is the engine's efficiency as compared with the Rankine cycle. Therefore, it is apparent that if cylinder condensation can be eliminated the efficiency will be greatly increased. Superheated steam will do this to a large extent.

It has been shown by a number of experiments that the best exchange between the steam and the walls of the steam engine is much greater when the walls are wet than when dry. It is desirable then to keep the steam dry until cutoff at least, or, better still, until release. To do this the steam must be superheated enough to raise the temperature of the walls, clearance spaces, etc., to that corresponding to the saturation temperature of the incoming steam. The superheat should not be carried high enough, however, to have superheated steam after release as that would represent a loss in economy.

The question is often heard: "If the gain by the use of superheated steam is so great, why has it not been used more?" The reasons are as follows:

1. There is a rapid deterioration of the superheater due to the oxidation of the tubes.

2. With saturated steam the water due to cylinder condensation acts as a lubricant, and the temperature of the steam is not great enough to disintegrate good grades of cylinder oil. With superheated steam, however, there is no cylinder condensation, except near release, and the temperature of the steam is so great that oil which lubricates satisfactorily with saturated steam is of no value at the high temperatures, and only recently has a special oil been manufactured that is of use at high degrees of superheat.

3. A valve that is steam tight at room temperature will warp badly at 400 or 500 degrees Fahrenheit. This can be overcome by regrinding the valve to its seat after having run it exposed to the superheated steam.

These are the principal troubles, but there are a number of lesser ones, including the need of special piping and fittings and special packing, greater trouble with expansion of the pipe lines, etc. These obstacles have been overcome in various ways and superheated steam is now being permanently adopted, especially in turbine work. Following are the results of a test where superheated steam was used to advantage. The engine was of 20 horsepower, simple noncondensing and took steam at 100 pounds gage:

Superheat, Degrees	Increase in Thermal Efficiency, Per Cent.	Steam per Indicated Horsepower, Pounds
0	0.0	39.2
98	12.0	33.4
254	51.4	23.1
321	70.8	19.8

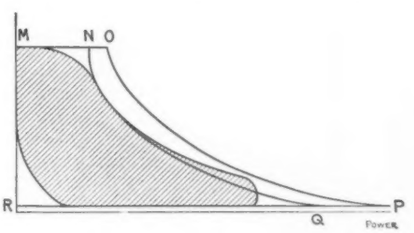


FIG. 2. ACTUAL AND APPARENT CONDITIONS IN CYLINDER

In this test it was found that a superheat of 270 degrees was necessary in order to obtain superheated steam at cutoff, and 325 degrees of superheat to have dry steam at release. The temperature of the walls did not exceed 400 degrees Fahrenheit with the steam entering the cylinder at from 615 to 650 degrees, yet as the walls were dry there was no great heat exchange.

In conclusion, it may be said that the general effect of superheated steam is to give almost constant efficiency both at full and at small loads, and to give the simple engine an economy nearly equal to that of the higher grades of compound engines.

A recent Australian invention to overcome troubles of corrosion and pitting in metals, especially boilers, due to electric chemical action of ingredients in water with which they are brought in contact, appears to have met with success in Sydney. The plan of the invention, according to *The Engineer*, is to introduce, by dynamos, weak electrical currents on to the metals intended to be protected, thus neutralizing the galvanic action of the corrosive substances contained in the water. The invention is expected to make an immense saving by eliminating the necessity for using zinc in various forms, boiler fluids, etc., to combat corrosive tendencies, and also in dispensing with retubings and other repairs. The process has been tried with success at Melbourne University.

Sampling and Analysis of Furnace Gas*

By J. C. W. Fraser
and E. J. Hoffman

Apparatus for collecting instantaneous samples and for collecting samples covering a period of time. Description of a measuring burette with which readings may be made with a great degree of accuracy.

*Abstract of a bulletin published by the Bureau of Mines, Washington, D. C.

The furnace conditions prevailing both in small plants and in large industrial establishments in this country are frequently far from satisfactory. If such conditions are to be improved, they must be more thoroughly understood, and means must be found to insure complete combustion of the fuel and yet to permit operation with such an excess of air as will result in the greatest efficiency.

In this work the services of the chemist are indispensable. A very important problem is the determination of the small

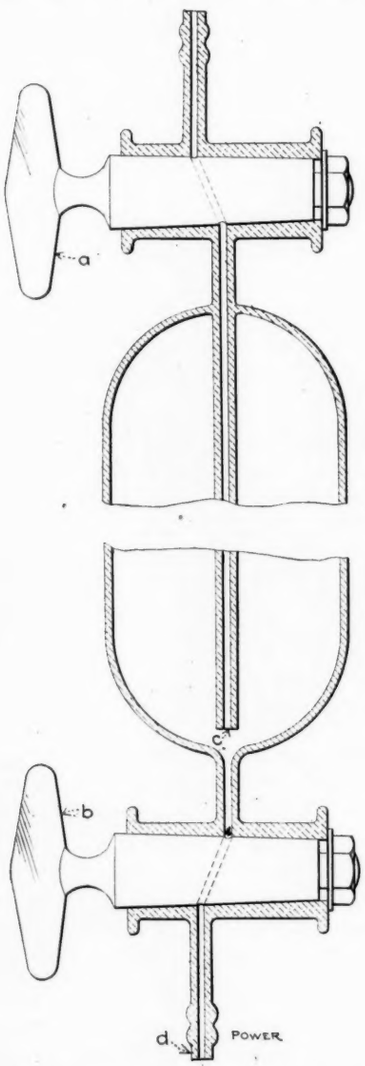


FIG. 1. GLASS VESSEL FOR HOLDING SAMPLE

percentage of unburned combustible matter that escapes from the furnace in the flue gases. Under ordinary circumstances so little as 0.1 per cent. of unburned combustible matter in a furnace gas is equivalent to about 1 per cent. of the fuel used; and for the determination of such small percentages of gas more accurate and refined methods are required than have ordinarily been available heretofore.

SAMPLING OF FURNACE GASES

The proper sampling of gases is frequently difficult when the gas mixture under investigation is not homogeneous and in sampling furnace gases the problem is further complicated by the necessity of protecting the part of the sampling apparatus introduced into the heated gases. It is not difficult to obtain a sample of gas from a given point within a furnace; but as in most cases the composition of the gas is constantly changing, some method must be provided by which the sample will represent the average composition of the gas at the point of collection during a desired period; or the sample must be collected almost instantaneously, so that it will merely represent the composition of the gas at the point and at the instant of collection.

A sample taken in either of these ways is only representative of the gas occupying a certain space surrounding the point of collection. In order to determine the average composition of the entire volume of gas it is necessary to multiply the number of samples and to distribute the points of collection in such a manner that the average of the samples will correctly represent the entire gas body. The number of samples taken should depend on the differences in composition that are presumed to exist throughout the volume of gas to be sampled. The difference in composition between samples taken at any two adjacent points of collection should not be greater than from 0.3 to 0.5 per cent.

CONTINUOUS SAMPLING

The sampling of flue gases can usually be accomplished satisfactorily by using a perforated iron pipe placed in the flue at the desired point.

A common method of collecting a sample is to attach a large bottle filled with water to the outside open end of such a sampling tube and then to allow the water to escape at such a rate that the gas, which replaces the water in the bottle, is collected in the desired time. It is not advisable to sample gases that contain a considerable proportion of carbon dioxide in this way because of the great ease with which water, or even a solution of common salt, dissolves that constituent and thus tends to equalize the content of carbon dioxide in the samples collected.

The following method was devised to obviate this difficulty as well as certain others.

COLLECTION AND STORAGE OF THE SAMPLE

The glass vessel illustrated in Fig. 1 is utilized both as an important part of the sampling device and as a holder for the sample after collection. The vessel should have a capacity of 150 to 250 cubic centimeters. If, when the vessel is in the position shown and is filled with mercury, the stopcocks *a* and *b* are opened the mercury will flow from the lower tube. The gas will then be drawn through the upper tube, enter the vessel at *c* and collect above the mercury. So long as the surface of the mercury remains above *c* the same volume of gas will be collected in each equal interval of the sampling period, and the sample obtained will be representative. The time required for a certain amount of mercury to run from the vessel can be varied from that taken when both *a* and *b* are completely open to a period of from 8 to 10 hours, or even longer, by attaching at *d*, by means of a rubber tube, a short piece of glass tubing drawn out to a smaller diameter. By trial these short glass tubes can be made of proper diameter to deliver the mercury at almost any desired rate.

After the sample has been collected, the tube above *a* is filled with mercury from a small funnel whose stem has been drawn out to a capillary. The vessel is then inverted and, by means of a rubber tube attached to a mercury reservoir, the inclosed gas is put under a pressure of about 100 millimeters of mercury. When the vessel is returned to its original position, as shown in the illustration, the stopcocks *a* and *b* are mercury sealed and there is no danger of gas leaking into or out of the vessel.

When removing the sample for analysis the vessel is again inverted and the tube above *b* is filled with mercury and attached to the burette. By means of the mercury reservoir previously used to put the gas under pressure, the desired vol-

ume of gas is forced out of the vessel into the burette. If the gas is to be measured over water, the tube above the stopcock *b* is filled with water instead of mercury.

In order to facilitate the safe handling of these vessels it is necessary to mount them in a portable stand, and frequently they are arranged in batteries of two to

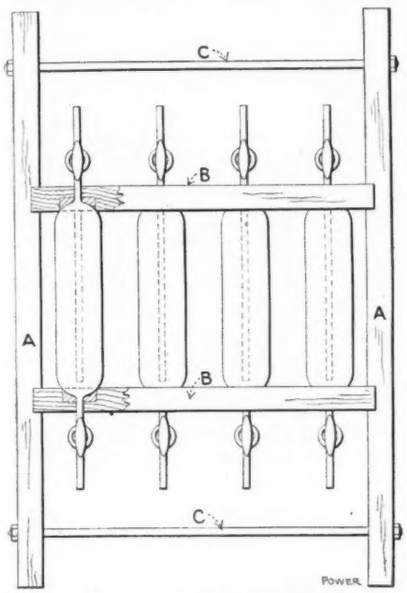


FIG. 2. RACK FOR MOUNTING SAMPLING TUBES

four each. Fig. 2 illustrates a convenient method of mounting four of these tubes.

WATER-COOLED SAMPLING TUBE

The portion of the sampling apparatus which is introduced into the furnace may be either a water-cooled metal tube or, better, a water-cooled quartz tube.

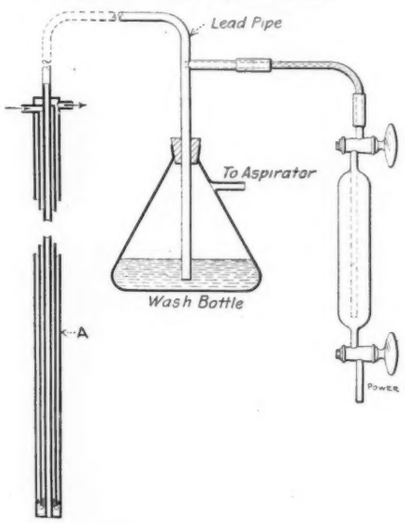


FIG. 3. WATER-COOLED SAMPLING TUBE

A satisfactory type of water-cooled metal tube is illustrated by *A* in Fig. 3. The inside tube, through which the gas is collected, is kept cool by cold water, which passes through the surrounding tube and returns through the outside annular space. When the inner tube is of quartz, the only difference in construction is the use of asbestos packing to insure a water-tight joint at each end. An apparatus provided with a quartz tube is more fragile than one wholly of metal, but it is preferable as it has a greater range of utility and may even be used in the fuel bed. This tube is connected directly with the mercury-filled sample receiver, and the sample is taken from the current of gas flowing through the lead tube.

To be sure that the current of gas is flowing properly through the tubes it is necessary to introduce a trap at some point beyond that at which the sample is taken from the lead pipe. The trap is simply a wash bottle containing water through which the gas bubbles on its way to the aspirator, the rate of bubbling roughly indicating conditions in the tubes. Fig. 3 illustrates the entire sampling system.

INSTANTANEOUS SAMPLING

Frequently it is desirable to know the composition of gases at some point in a furnace at a certain definite instant, particularly when there might be reason to suspect that the gases would decompose during a period of continuous sampling or when studying the progress of reactions in the furnace. This method is employed by certain investigators in collecting samples from the flame of burning gases and from the explosion flame of coal dust, etc. The use of this method also enables one to obtain certain information concerning furnace conditions which he might not be able to obtain by the use of the continuous-sampling method. It was for the purpose of collecting instantaneous samples that the device shown in Fig. 4 was constructed.

DESCRIPTION OF APPARATUS

The apparatus consists of a quartz sampling tube of 100 cubic centimeters capacity, immersed in water contained in the steel tube *B*, which is 1.2 meters in length and 10 centimeters in diameter. At each end the vessel terminates in a thick-walled quartz tube, 1-millimeter bore, provided with a stopcock as shown. One of the tubes *b* extends 150 millimeters beyond the stopcock and the open end projects beyond the end of *B*. An enlargement 60 millimeters from the stopcock gives a firmer hold for the cement of litharge and glycerin with which the cavity in the collar *c* is filled; in this way *c* is fastened permanently to *b*. The brass device for opening and closing the sampling tube from the outside is supported by the two end pieces *e* of the steel tube *B*. It consists of the brass frame *C*, in which is supported the mechanism for turning the stopcock. This includes the brass shaft *h*, on which is set the wheel *i* and, beneath the frame, the brass plate *l*, carrying four projections, *g*, which fit around the handle of the stopcock. To avoid straining the stopcock in turning, which might occur if *h* were not centered above the stopcock, the pieces *g* are small rollers. The face of the wheel *i* is threaded to engage with the threaded end of the brass rod *r*. The piece *k* serves as a guide for the brass rod and affords a means of adjusting the threaded end of the rod to the face of *i*. The adjustment is accomplished by having the hole in *k* through which the rod *r* passes eccentric to the bearing of *k* in *C*. A movable stop, *m*, can be set to limit the rotation of *i* and the extent to which the stopcock may be turned.

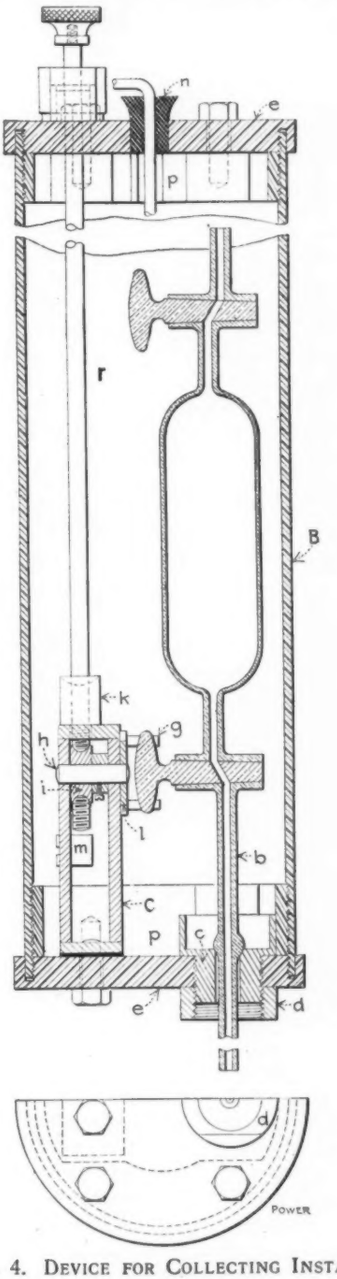


FIG. 4. DEVICE FOR COLLECTING INSTANTANEOUS SAMPLES

OPERATION OF APPARATUS

Before collecting a sample the end piece *e*, which is to carry the vessel

is removed; then the quartz tube is placed in position and the nut tightened. During this operation *c* is prevented from rotating by two small dowel pins which enter holes provided for them in *e*. By trial, *m* is adjusted so that when the rod *r* reaches it the handle of the stopcock is rotated 90 degrees. It is customary to adjust the stopcock so that communication with the vessel is established when *r* is against *m*; the withdrawal of *r* then closes the stopcock. Having the stopcock properly adjusted, the end piece *e* is bolted to *B*, and the latter is vertically suspended by a handle clamped on the other end. While in a vertical position the rod *r* is introduced through the brass bushing at the upper end and finds its way without difficulty into the hole in *k*. The steel tube *B* is filled with water through *n*, which is then closed by a perforated rubber stopper, through which passes a short glass tube bent at a right angle, its projecting end being directed upward when the apparatus is in use. This tube relieves the internal pressure when the temperature of the water rises.

The apparatus is then taken to a vacuum pump and placed in a horizontal position in two semicircular rests which prevent its moving while it is connected with the pump. When the tube *A* is exhausted, and while it is still connected with the pump, *r* is withdrawn so far that the threaded end leaves *i* but remains in *k*, thus closing the stopcock. The time at which *r* and *i* become disengaged can be readily determined by the increased ease with which *r* moves. The pump is disconnected, and as soon as convenient the apparatus is introduced into the furnace, the open end of the tube *b* being placed at the point from which the sample is desired. The stopcock is opened by pushing in the rod *r* until it is in contact with *m*, and after the short time required for the vessel to fill the rod is withdrawn and the stopcock thus closed.

As the sampler remains in the furnace only about 30 seconds and as the quantity of water in *B* is considerable, it is unnecessary to provide for a circulation of this water. In collecting a sample it was found that the temperature of water in *B* did not rise more than 10 degrees, even when the tube was inserted in the hottest part of the furnace.

After removing the apparatus from the furnace, the water is drained from *B*, the rod *r* is withdrawn, the nut *d* is started to insure its subsequent easy removal, and the end piece *e*, carrying *b*, is removed. Then *d* is taken entirely off, and after the two glass tubes have been filled up to the stopcocks with mercury the sample is transferred to one of the holders illustrated in Fig. 1. Since it requires about 30 minutes for the complete operation of collecting a sample in this way, a series of samples is generally collected and stored in the holders before making the analyses.

Determination of Moisture and Nitric Oxide

With the apparatus illustrated in Fig. 4 the amount of water vapor accompanying a gas sample can be easily known by absorbing the moisture and weighing it. Likewise, the presence of traces of nitric oxide in furnace gases has been shown by using a simple modification of the method just described. The determination of nitric oxide is accomplished as follows:

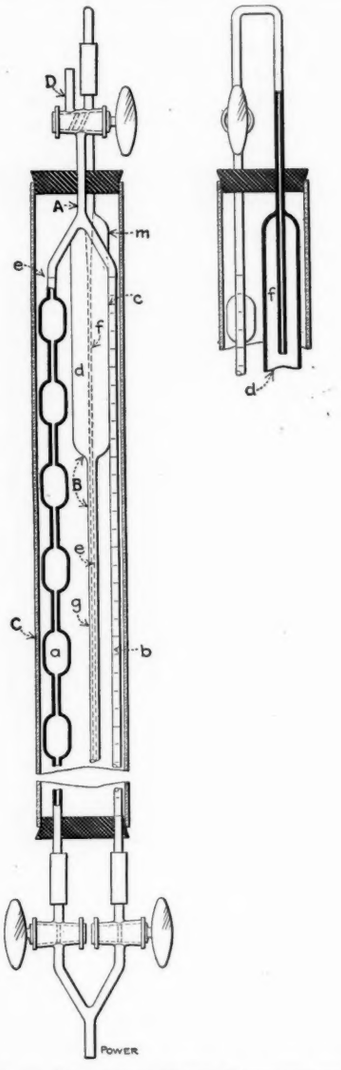


Fig. 5. Sampling Tube Containing Compensating Device

The sampling tube used is a water-cooled quartz tube similar to the one illustrated in Fig. 3. An evacuated 8-liter bottle is used as a receiver for the gas sample in place of the quartz vessel in Fig. 4. Two glass tubes, each provided with a carefully ground stopcock, pass through two holes in a rubber stopper which closes the bottle. One of these tubes extends almost to the bottom of the bottle; the other, which ends just below the stopper, is bent at a right angle and connected directly with the water-cooled quartz tube.

After the collection of the sample, an excess of an alkaline solution of potassium permanganate is introduced into the bottle and allowed to stand for 24 hours, when the solution is withdrawn and the free ammonia distilled off. Potassium hydroxide and fine aluminum powder are then added and the mixture allowed to stand several hours, after which the ammonia formed is distilled into standard sulphuric acid.

The presence of nitric oxide can be demonstrated qualitatively by introducing a solution of starch and potassium iodide into the bottle directly after the collection of the sample. The blue color does not appear immediately, probably owing to the presence of sulphur dioxide in the gas, but in a short time the color becomes quite pronounced.

In the gases examined the quantity of the nitric oxide found varied from 0.015 to 0.031 per cent. At the time of taking these samples the furnace conditions were not favorable to the formation of this constituent, and it is believed that the percentage of nitric oxide in the furnace gases is frequently much greater.

Analysis of the Sample

The sample having been collected, its analysis is made most conveniently by the method of Hempel. The use of mercury in the burette is to be preferred to that of water; but whichever is used, the burette should always be provided with a water jacket to avoid errors due to sudden changes in temperature. While the ordinary Hempel burette is sufficiently accurate for most purposes, it does not enable the observer either to detect or to determine changes in volume amounting to 0.1 cubic centimeter or less, since the error in reading the burette itself cannot be less than this volume.

It is of some importance to be able to measure smaller percentages of combustible gases than can be determined by the ordinary Hempel method, since the flue gases are so diluted that a small percentage of combustible matter in them corresponds to a much greater percentage of the fuel. To find these small percentages, a very accurate method is required. The apparatus described by Hempel for exact gas analysis, which provides a tube for compensating errors due to variations in the pressure and temperature of the atmosphere (the principle of Pettersson), is in certain respects unsatisfactory. In this instrument a considerable portion of the air in the compensator and an approximately equal volume of the gas being measured are not inclosed in the water jacket, and while there is a tendency to equalize any error due to this arrangement, the compensation is perfect only when the total volumes of the two

gases are equal. Further, the burette itself cannot be read with sufficient accuracy.

In 1900 A. H. White published a description of an apparatus devised to obviate these difficulties, in which the principle of automatic compensation for changes in temperature and pressure as suggested by Pettersson and modified by Hempel and others is utilized in an improved form. Its measuring portion consists of two limbs, suggested by the burette of Otto Bleier, one a series of bulbs to contain the larger portion of the measured gas, the other a long straight tube of small capacity on whose scale all final readings of volume are made.

To obviate the same difficulties and to measure all possible changes in volume the apparatus described below was designed by the writers.

Description of Apparatus

The apparatus, illustrated in Fig. 5, consists of the burette *A* and the automatic compensating device *B*. The measuring portion of the burette *A* and the whole of the compensator *B* are inclosed in the water jacket *C*. The measuring portion of the burette consists of the two limbs *a* and *b*, the graduated portions of which are 66 centimeters long and united at the top in an inverted Y-shaped connection to which a Greiner-Friedrich two-way stopcock is attached. Through this stopcock communication can be made with either of two short, thick-walled tubes of small bore, one of which is connected with the compensating device. Outside the water jacket *C*, at the lower end, is a second Y tube, each limb being provided with a stopcock and attached by rubber connections to the projecting ends of the limbs *a* and *b*. To the lower end of the Y tube is attached heavy rubber tubing connected with a mercury reservoir.

The tube *a* consists of a series of 10 bulbs, each having a capacity of 10 cubic centimeters between the two graduation marks immediately above and below it. The straight glass tube *b* has an internal diameter of about 4.5 millimeters, and its graduated part has a total capacity of 10.1 cubic centimeters. The beginning of the graduated portion of each limb of the burette is at *c*. The compensator *B*, while utilizing Pettersson's principle of counterbalancing the pressure of the gas to be measured with that of a constant mass of air occupying a constant volume, is arranged in a somewhat different form from his device. The confined air, whose pressure at a constant volume is equalized by that of the gas to be measured, is contained in the bulb *d* and above the mercury surface *e* in the tube *g*, which forms the lower termination of the bulb.

The glass tube *f* is connected at its upper end with one of the communications through the stopcock of the burette and is sealed into the top of the bulb *d*. Its other end extends nearly to the bottom of *g* and opens beneath the surface of the mercury. The diameters of the tubes *f* and *g* are proportioned so that the distance from the inside of *g* and the outside of *f* is as nearly as possible equal to the internal diameter of *f*.

The compensator may be filled so that the readings on the burette are the correct volumes of the gas at 0 degrees Centigrade and 760 millimeters pressure, or it may be closed under known conditions of temperature and pressure and the readings corrected to standard conditions. The latter method is sufficient for most purposes, and when it is used the compensator may be closed by replacing the seal at *m* by a small tube and stopcock.

Operation of Apparatus

By drawing nearly all the gas into the limb *a* and adjusting the pressure to approximately that of the atmosphere, the number of bulbs the gas will fill completely when at the pressure of the air in the compensator may be ascertained. Having determined this, the mercury in the burette is brought exactly to the level of the graduation beneath the last bulb completely filled in the trial experiment and the stopcock at the bottom of the limb is closed. The remaining fraction of a bulb full of gas is then made to enter the limb *b*, and the two-way cock is turned so as to place the burette in communication with the compensator. The pressure of the gas in the burette is then adjusted, by means of the mercury reservoir, until the two surfaces of mercury in the compensator are on the same level. The pressure of the gas in the burette is then equal to that of the gas in the compensator. The stopcock at the bottom of *b* is then closed and the reading of the burette taken. To this reading is added the predetermined capacity *K* of that part of the apparatus between the graduated portion of each limb of the burette and the mercury meniscus in the tube *f*. As each constituent of the gas is made known by the difference in the burette readings, before and after an absorption, this constant capacity *K* does not enter into the determination of the amount absorbed. But it is necessary to apply this correction to obtain the initial volume of the gas unless exactly sufficient nitrogen to fill this part of the apparatus is taken into the burette previous to the introduction of the sample.

The reading of the burette requires some practice to secure the best results, but with experience it can be accomplished quite readily and with extreme accuracy. The gases are measured in the moist condition, and the quantity of water introduced into the burette and compensator to effect this must be only sufficient to moisten the walls of the glass tubes. If there is enough water in the compensator to drain down upon the mercury, the accurate adjustment of the mercury surfaces is rendered difficult; while too much water in the burette is likely to stop up the narrow tubes connecting the bulbs and in this way to interfere seriously with the distribution of pressure on the gas in the burette and consequently with the equalization of the pressures in the burette and compensator.

With this apparatus a complete analysis of gas may be made in the usual way by connecting the burette in turn with various absorption pipettes.

Degree of Accuracy Attainable

The limb *b* of the burette on which the readings are made is graduated in hundredths of 1 cubic centimeter, and tenths of these divisions can be estimated quite accurately. Experiments have shown that 50 to 100 cubic centimeters of gas can be measured accurately to 0.01 cubic centimeter. With volumes less than 50 cubic centimeters the readings can be more precise as a more accurate adjustment of the mercury surfaces in the compensator is possible.

Water Resources of Minnesota

The coöperative agreement between the United States Geological Survey and the Minnesota State Drainage Commission for the purpose of investigating the water resources of Minnesota has recently been renewed, and in consequence of an appropriation of $30,000 made by the legislature for two years' work, the investigations are being extended into portions of the State not previously touched.

The general plateau level of the northeastern portion of Minnesota, the section which lies north of Lake Superior and is contained chiefly in Lake and Cook counties, is more than 600 feet above Lake Superior. Numerous streams drain this region into the lake, and although they are small the fact that they descend 600 feet within a few miles of the lake makes them important as sources of water power. Many of the streams pass through cañons having vertical walls which would make excellent dam sites. The investigation has been started by making a survey of Pigeon (which forms the extreme eastern boundary between Minnesota and Ontario), Brule and Deviltrack rivers. Other streams to be surveyed are Cascade, Poplar, Temperance, Cross, Manitou, Baptism, Beaver and Gooseberry rivers. Besides the streams in the northeastern portion of the State, Vermilion, Big Fork and Little Fork rivers are being surveyed.

Measurements of the flow of the rivers are also being made, to determine more fully their value for water power.

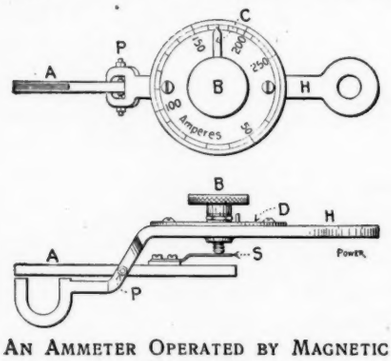
Electrical Department

Especially conducted to be of interest and service to the men in charge of the electrical equipment

A Magnetomechanical Ammeter

A highly ingenious current-measuring instrument, based on the law of magnetic traction, has been brought out by an English firm. It consists of an incomplete "loop" built up of laminated iron, which forms a horseshoe electromagnet when in use, and a laminated armature *A* pivoted at *P* in a pair of jaws formed in the handle *H* to which the loop is attached.

When using the instrument, the loop is applied to the conductor carrying the current to be measured and the armature *A* closed against the ends of the loop, the screw *B* being backed off away from the spring *S*. The current in the wire magnetizes the closed circuit of laminated iron formed by the loop and the armature *A*, and the force with which armature is held against the ends of the U is proportional to the square of the magnetic flux. The cross-section of the



AN AMMETER OPERATED BY MAGNETIC TRACTION

iron in the loop and armature is such that the flux is proportional to the current in the conductor, within the range of the instrument; therefore, the magnetic pull on the armature is proportional to the square of the current in the conductor. The magnetic pull is measured by turning the screw *B* until the spring *S* is flexed enough to throw the armature away from the magnet poles formed by the ends of the loop. When this occurs, the pointer *C*, which is attached to the thumbscrew *B*, will indicate on the dial *D* the current flowing in the conductor embraced by the loop.

The practical advantages of the instrument are many; among them are the facts that it can be applied to any live conductor within its range without interrupting the circuit or adding resistance to it, and it is small, substantial and easily carried in one's pocket. Presumably, the degree of accuracy is not as high as that of an ammeter of the galvanometer type, but it may easily be made to give readings sufficiently accurate for the purposes of circuit inspection, trouble location, etc.

Central Station Service vs. Isolated Plant Operation

BY HENRY D. JACKSON

During the past few years we have heard a great deal as to how much cheaper it is to purchase power from a central station than it is to generate it in an isolated plant. The central station advocates claim a great many advantages, among them being a reduction in the plant cost, thereby greatly reducing the fixed charges on the plant; a reduction in the insurance on the plant, owing to the absence of high-pressure steam; reduction in labor, both manual and executive; the value of the space left available by taking out the factory plant, and the space formerly occupied by belts and belt boxes; reduction in the loss of productive capacity, owing to the complete avoidance of power failure, and the entire elimination of auxiliary service. There are still other factors which they take into account and which I will consider later. Practically all but one of the claims just cited is open to argument, the exception being the space left available by cutting out the factory plant, and this is by no means an entire gain in many cases, as much of the space vacated by the isolated plant is frequently occupied by the switches, transformers and meters for the power supply.

In considering the reduction in the plant cost, this factor naturally enters into the cost of power as produced in an isolated plant; but the central station agents are not satisfied to take into account only the factors which should enter into the plant cost; they desire to tack on an additional figure which is frequently as large as, or larger than, all the rest of the fixed charges put together, this being the item mentioned as profit ratio. It is frequently a fact that the reports, as shown to a prospective purchaser by the central-station sales agent, would not be sufficiently strong to warrant the purchaser in adopting central-station service unless this profit ratio were taken into account.

The power plant is quite as necessary a part of the manufacturing business as is the building in which the work is carried on. When a manufacturer goes into business, he has the choice between erecting a building for himself, or renting one. If in his opinion he can put up a building cheaper than he can rent one, he puts it up, but he does not figure that he must make the same profit on the money invested in his building that he does on the manufacturing or other operations of his business. He simply compares the normal fixed charges on the cost of the proposed building with what he will have to pay if he rents one. Exactly the same procedure should be followed with reference to the question of generating power or purchasing it.

I believe it would be hard to find a manufacturer who has succeeded in getting a reduction in his insurance through eliminating his power plant and adopting purchased power. So long as he keeps a boiler with fire under it and requires steam for either heating or manufacturing purposes, so long will his insurance rate remain practically the same as it was before he removed his engine.

With reference to labor, that of the fireman or part of it may be eliminated by the substitution of central-station service, and it may be possible to do away with the operating engineer, but some one having engineering knowledge and experience must be kept on the pay-roll in order to see that the plant is operated efficiently, and that the general transmission apparatus is kept in good order.

Executive attention will not be eliminated. With a properly designed cost system, and a report sheet from the power plant, the executive attention required by an isolated plant is very small, particularly if the engineer is a good one; if he is not, a good deal of executive attention may be required, but it speaks very poorly for the executive if a poor engineer is allowed to hold his position long. With power generated

at the plant, a very few minutes each day will enable the executive head to keep close track of the coal used, the power generated and water evaporated per pound of coal, and the cost of power per unit of production; the general work of the clerical force will be comparatively small. With power purchased, the same executive attention would be required if a plant were properly operated, because the executive head should know how much power is used from day to day, and how much per unit of output, as this would give him a line on the general behavior of the machinery throughout the plant and the cost per unit of output; practically the same amount of attention would be required from the clerical force. In addition to this, either the executive head or some one else would have to check up the bills rendered by the power company, and those of us who have had experience in checking up bills on a sliding-scale basis, which is so commonly in use, realize that it is by no means an easy job. Thus it would seem that the executive attention required when using purchased power would be quite equal to that required for isolated-plant operation.

The loss in productive capacity is pretty hard to figure. It is my opinion, based on some years of observation and experience, that an isolated plant, well built and cared for, is quite as free from shutdowns as any equipment operated from central-station service; in fact, it can be made much more satisfactory than much of the central-station service of which I have had knowledge.

The value of auxiliary service depends entirely upon the method of operating an isolated plant. With shaft and belt transmission, it is frequently hard to operate any single department without driving a great deal of useless shafting, but separate department operation is, as a rule, very infrequent, and in most plants it is found that but one or two departments require overtime service, and usually the same departments, so that it would be a comparatively easy matter to install motors to operate this portion of the plant on a pinch, supplying the power from the generator used for lighting purposes.

It would seem, therefore, that for the most part these arguments for bought power are not really of much importance, although they frequently can be made to appear so by the central-station expert. A careful analysis, however, of central-station claims in comparison with what can be done in an isolated plant will usually result in these arguments being demolished.

The central-station salesman also frequently makes the statement that the cost of heating by exhaust steam is equal to or greater than that of heating by live steam, as the back pressure on the engine resulting from the use of exhaust steam compels the use of more steam for the engines than they would otherwise use; the argument has also been advanced that the heat in the exhaust steam is not sufficient to warrant using it for heating purposes, as it will not give effective results. They further claim that it is better economy to use a condensing type of engine, using live steam for heating, than to operate a non-condensing engine, using exhaust steam for heating. All of these arguments need careful consideration.

In the first place, there is no necessity for any back pressure on the engine, with a properly designed heating system. In the second place, exhaust steam is quite as efficient for heating as live steam, with a properly designed heating system. The very slight difference between the temperature of steam at 5 pounds gage and that at atmospheric pressure is not worth consideration except under very special conditions. The question of running condensing or noncondensing is entirely apart from the question of heating, and it is settled entirely upon the basis of whether the amount of coal saved by running condensing will pay for the additional apparatus installed and the additional water required for condensing purposes. Under most conditions exhaust steam is most economical, for a large percentage of the factory plants find it more economical to run condensing than non-condensing. The central agents claim that as much more coal is required to operate the heating system under these conditions as would be required to operate the heating system if the engine were not in operation. Any one who has ever analyzed this question fully will appreciate the absurdity of such a claim. If the exhaust steam is just equal to that required for the heating system, the cost of the coal can be considered as the cost of heating, thereby reducing the cost of the power by just that amount. As the amount of steam used by the engine increases beyond that required for heating, its value as a heating medium will decrease until if the steam used for heating is a negligible amount as compared to the total steam used for the engine, then the question of heating is entirely eliminated from the cost of power operation at the plant. This is a condition rarely, if ever, reached.

The whole general method of attack by the central-station salesman on the isolated plant is open to criticism, and the only reason that they succeed in many cases is that the plant owner or manager is, as a rule, not a power expert, though he may be a good business man, and understand how to figure what it costs him to produce his goods and at what price he must sell them to make a profit. His power plant is usually left entirely in the hands of his engineer, and while he is interested in making a saving in his power plant, he has neither the time nor the knowledge to detect the weak points in the arguments of the central-station experts, who are trained in formulating plausible arguments. Many power plants have been displaced by central-station power upon reports which, if carefully analyzed, would show far greater opportunities for saving in other directions than by adopting central-station power; not a few of them have been discarded entirely through the influence of that absolutely unjustifiable factor, profit ratio.

An illustration of the methods employed by the central-station experts is afforded by a report form used for securing factory loads for central stations, which was described by Mr. Perry in a recent issue of *The Electric Journal*. The form is an excellent one, but the material used and the results derived are open to much criticism. Mr. Perry's filled-out report describes a power plant of four 200-horsepower Heine boilers, installed in 1901; a Corliss engine, 36x72, also about 10 years old, belted directly to the line shaft, and the necessary auxiliaries. The engine indicated 520 horsepower average, 615 maximum, and a minimum of 470. The friction load of engine, shafting and loose pulleys was 260 horsepower. The report states that the evaporation of 5.2 pounds of water per pound of coal was being secured, the coal being a half-and-half mixture of pea and Pocahontas. In order to burn this coal forced draft was necessary, this being furnished by means of a 7x8 Ajax engine driving a Sterling blower. It is interesting to note the rate of evaporation, and the fact that four boilers of 200 horsepower each were required in order to furnish steam for a Corliss engine with a maximum load of 615 indicated horsepower. What type of a man was the engineer who would allow a Heine boiler to get in such a condition that it would only evaporate 5.2 pounds of water per pound of coal, and who would consider for a moment the necessity for operating four 200-horsepower boilers to furnish steam for 615 indicated horsepower in a Corliss engine? Evidently neither the manager nor the engineer was acquainted with his work. If these boilers had been kept clean an evaporation of 10 pounds per pound of coal would have been practicable; the steam could have been made by two boilers, and the coal bill reduced one-half; this would also allow the elimination of a fireman.

It is quite evident that the first medicine required in this plant, according to the report itself, was not central-station power, but a new engineer. It is reasonable also to assume that if the boilers were allowed to get in the condition indicated, the engines and heat-

ing system were quite as bad, and probably all work throughout the plant which came under this engineer was equally bad. Nothing was said in the report to indicate any necessity for improvement in the condition of the steam plant.

The report states that under the present condition of operation the executive attention costs about $500 a year, whereas under the head of central-station power no charge is made for executive attention. Earlier in this article I have called attention to the necessity for executive attention in both cases.

Under the head of "Loss of Production," the report gives an item of forced shutdowns aggregating about one day per year at a cost of $500 per year in production labor alone. After considering the conditions noticed at the boilers it is not hard to understand that there would be forced shutdowns. The wonder is that there were not more of them.

Under the head of "Motor Drive," there are specified motors to the capacity of 572 horsepower, with the erection and wiring, at a total cost of $5927. It is pretty hard to see how motors could be purchased and installed, with the wiring, at this price, even though the installation were made by the millwright force of the plant. Certainly the time of these men should be charged up to this work, and the motors, unless presented by the power company, would probably cost considerably over $4527, unless they were of a type totally unfitted for the work, which not infrequently happens. The central-station agent is very anxious to make the cost of the installation as low as possible, and he therefore recommends the use of the highest speed motors obtainable, frequently disregarding the fact that these motors are by no means economical in their operation, owing to the very short distances between shaft centers often necessary in factory plants.

Under the head of "Factory Heating," the report states that exhaust steam no longer being available, low-pressure live steam will be used, and the amount of coal required for factory heating and for the dipping department will be computed with reference to the radiating surface. "Comparing this factory with others whose coal consumption for heating is known, we would assume that 510 tons of coal per year would be required." This item is absurd on the face of it. The question here is not what other factories have done, but what this factory is going to do. The factory has been generating steam at the rate of 5.2 pounds per pound of coal, and therefore the coal required to make steam for heating must be based upon an evaporation of 5.2 pounds and not upon an assumed evaporation of 8, 9 or 10, as is done in other factories. Under these conditions the coal bill will be, at the lowest estimate, twice the quantity assumed, and it is pretty evident that an engineer who would allow the evaporation to fall to 5.2 pounds is likely to have a heating system which is decidedly inefficient, with the result that the coal bill for heating is more likely to be three times the estimated value than twice.

The final results of this report are highly interesting. According to it, the total annual cost of light, heat and power as at present produced is $28,347. The cost of central-station service is given as $23,324, or a saving of $5023. To this, however, as outlined above, we should have to add $500 for executive attention and $4000 for coal, reducing the total saving to $523.

What would be the saving if the plant were operated in the hands of an engineer who knew his business? His first duty would be to overhaul the boilers, which would result in a saving of one-half the coal, costing $7500. He would next get rid of a fireman, saving approximately $800, or making a total saving of $8300, and he would undoubtedly make numerous other savings by bringing the plant into a proper condition as to both power development and heating. It is clear, therefore, from a careful consideration of the report, that a much greater saving can be made by putting the existing plant in proper condition than by the use of central-station service.

LETTERS

Cutting Out Dynamos in Parallel

The precautions in cutting out one of two dynamos suggested by Mr. McKelway on page 214 of the August 8 issue might have been necessary fifteen years ago, but I do not think quite such careful nursing is necessary with modern machines. Railway generators are subjected to instantaneous changes of load which are much more severe than that which caused "W. H. L.'s" governor to hang up, and lighting generators are equally able to stand such changes, except, perhaps, in the matter of sparking. Even in this respect, a modern dynamo that would not take an increase from one-third to full load without giving trouble would not be considered a first-class machine.

By the foregoing I do not mean to intimate that shifting some of the load before cutting out a machine, as suggested by Mr. McKelway, is a worthless refinement; on the contrary, it is a good thing to shift most of the load in order to avoid dealing unnecessary sudden shocks to the engine as well as the generator armature. But I do not consider it necessary on the ground of sparking.

FRANCIS W. APPLETON.

Baltimore, Md.

What Displaced the Brush Holder?

On going to work a few nights ago I found the day engineer industriously sandpapering the commutator of what was once a 35-kilowatt belted generator but has been changed into a motor and

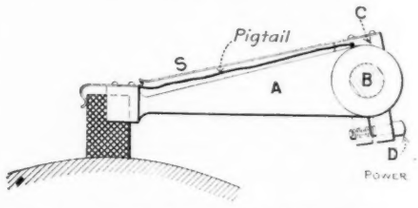


FIG. 1. TYPE OF BRUSH AND HOLDER USED

is driving a 9x13-inch ammonia compressor. I found upon inquiry that the trouble was caused by one of the brushes becoming displaced from its normal position. The brush holder is of the pivoted type represented in Fig. 1, a cast-brass arm *A* being mounted on the stud *B* so it is free to turn on the stud. The brass tension spring *S* is fastened to a clamp collar *C* which is also on the stud *B* and is clamped to it by the screw *D*.

The brush holder, by some unknown means, became thrown over to the position indicated in Fig. 2 and the results were a badly burned commutator and a shutdown. The pigtail was burned off at the point of attachment to the collar and

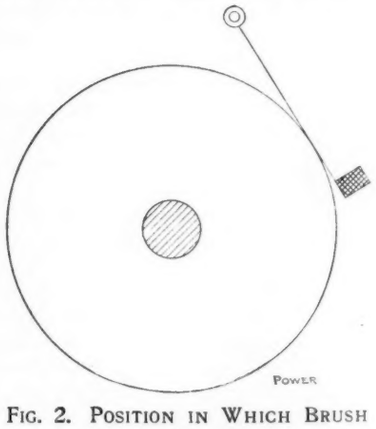


FIG. 2. POSITION IN WHICH BRUSH HOLDER WAS FOUND

the main circuit-breakers blew out, putting the whole system in darkness.

There was no one in the engine room at the moment, so far as we know, the engineer being in the boiler room, and we are unable to account for the displacement of the brush holder. If any other reader has had a similar experience and can give an explanation of it, I will appreciate the information.

EDGAR ALTMAN.

Cincinnati, O.

Gas Power Department

Everything worth while in the gas engine and producer industry will be treated here in a way that can be of use to practical men

Apparatus for Passing Gas Samples to a Calorimeter

By O. C. Berry

Mr. Parmely's article in a recent number of Power describing the use of a water aspirator for taking samples of gas from a suction gas producer for delivery to a Junkers calorimeter was read with much interest by the present writer. Under the special conditions existing in the case cited, the water used in the aspirator had probably just been through the wet scrubber and, consequently, was partially saturated with the gas. If that was true, the error in the results obtained may have been comparatively small, but in general, using an aspirator for such a purpose would lead to an error of important magnitude, because water absorbs a considerable portion of the constituents of producer gas.

Producer gas, of course, is a mixture of several individual gases, chiefly carbon monoxide, hydrogen, carbon dioxide and nitrogen, with some methane and negligible quantities of oxygen and ethylene.

According to Hempel's "Gas Analysis," one cubic foot of water will absorb five of these gases to the following extent, at 20 degrees Centigrade: Hydrogen 0.01819 cubic foot; carbon dioxide, 0.9 cubic foot; carbon monoxide, 0.02312 cubic foot; methane, 0.0349812 cubic foot; ethylene, 0.1488 cubic foot. Each of these figures is the quantity of gas that the water will have absorbed when it has become saturated with that gas, the gas itself being at atmospheric pressure and 20 degrees temperature.

To ascertain the amount of each gas that the water can absorb from the mixture representing producer gas, each of the foregoing figures must be multiplied by the percentage which the corresponding gas represents of the whole.*

The volume of gas delivered by a water aspirator per cubic foot of water used will vary with the design of the aspirator, the water pressure and the pressure against which the gas is delivered. The aspirator investigated in the laboratory at the University of Wisconsin will deliver about half a cubic foot of gas per cubic foot of water used, the water pressure being 60 pounds per square inch and the gas being delivered against a back pressure of about 10 inches of water. Using these figures as the basis of computation, the effect that the absorptive qualities of the water would have upon the composition of the gas would be as shown in Table 1, for producer gas of the composition stated in column 1. The volume of each gas that can be absorbed by 1 cubic foot of water is multiplied by 2, in order to obtain the figures in columns 3 and 4, because 2 cubic feet of water are required to aspirate 1 cubic foot of the composite gas. The reason for not figuring on any of the oxygen or nitrogen being absorbed is that the water used in the aspirator will in every case be saturated with air and will therefore not be capable of absorbing either of these gases.

*Henry's law; Newth's "Organic Chemistry."

TABLE 1

1 Gas	2 Per Cent. by Volume	3 Coefficient of Solubility in Water × 2	4 Volume Soluble in 2 Cu. Ft. of Water Under Partial Pressure	5 Volume of Gas Left Unabsorbed	6 Per Cent. by Volume in Final Gas
CO_2	10	1.8	18.0	0	0
CO	20	0.046	0.92	19.08	21.58
H	8	0.036	0.29	7.71	8.72
CH_4	3	0.070	0.21	2.79	3.15
C_2H_4	0.5	0.30	0.15	0.35	0.40
O_2	0.5	0.0	0.0	0.50	0.56
N	58.0	0.0	0.0	58.00	65.59
				88.43	100.00

one might expect, but it is quite appreciable. In the particular case cited above it would be as shown in Table 2, all of the heat values being reduced to zero Centigrade and 29.92 inches of mercury pressure, and the lower heat value of hydrogen being taken.

The absorptive effect of the water is obviously greatest in the case of the CO_2, which will ordinarily be removed almost if not entirely. The change in the heat value of the gas will therefore be affected most by the percentage of CO_2 in the original gas; it will also vary with the number of cubic feet of water actually used in aspirating 1 cubic foot of gas and the degree of saturation of the water before and after its contact with the gas. The error obviously may be important and it is one for which correction cannot be satisfactorily made, even approximately.

There are, however, two methods that can be used to draw gas from a suction plant without entailing the error described. Fig. 1 illustrates the apparatus for applying one of these; this equipment is the easier of the two to install. It consists of a small gasometer, the tank of which is about 2 feet in diameter and 3 feet high and the "lift" is provided with a nozzle to take a small hose connection. This connection leads through a tee to the gas main and to the calorimeter, as indicated in the sketch.

TABLE 2

Gas	Per Cent. by Volume, Original Gas	Per Cent. by Volume, Final Gas	B.t.u. per Cu.Ft. of Gas	B.t.u. in Original Gas	B.t.u. in Final Gas
CO	20.0	21.6	342	68.40	73.87
H_2	8.0	8.7	298	23.84	25.93
CH_4	3.0	3.2	964	28.92	30.85
C_2H_4	0.5	0.4	1573	7.68	6.29
Total				129.02	136.94

From the figures in the table it is evident that the gas that reaches the Junkers calorimeter may be very different from that which flows in the producer main. The effect that this change in chemical composition will have on the heat value of the gas is not so great as

To operate such an outfit the tank is filled with water that has been saturated

with the gas. To saturate the water, a quantity of gas several times the volume of the water must be bubbled through the water, or water that has just been through the wet scrubber can be used. Then the lift is immersed in the water so deeply that all the air is driven out of it and the water level is up to the connection for the rubber tube. The rope for raising the lift is then run through

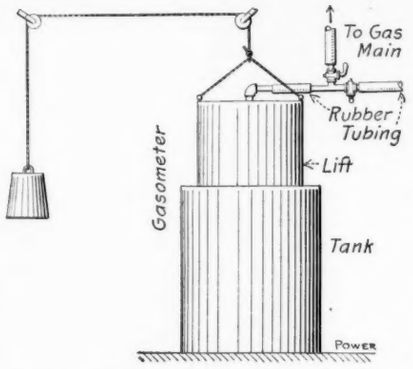


FIG. 1. SIMPLE APPARATUS FOR TAKING GAS SAMPLES INTERMITTENTLY

the pulleys above and a weight somewhat lighter than the lift is hung on the other end of it. Next the pipe leading to the Junkers calorimeter is closed off, the one connected to the gas main is opened and the gasometer lift is allowed to take in the desired amount of gas. When this is done the weight is removed from rope, the valve in the pipe to the gas main is closed and the one in the calorimeter pipe is opened; the weight of the lift will force the gas through the calorimeter.

When this charge has been tested, the operation can be repeated, of course, but samples cannot be tested much more rapidly than three times an hour if each test is checked by making two determi-

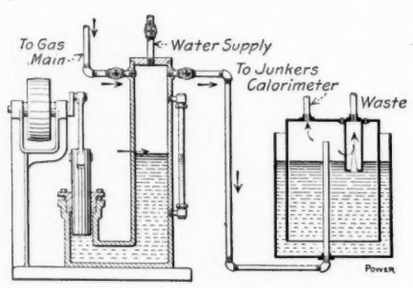


FIG. 2. MORE ELABORATE APPARATUS FOR CONTINUOUS SAMPLING

nations upon each sample. The advantages are that the equipment is simple and easy to install, and the continuous contact of gas and water during operation keeps the water saturated with the gas and prevents changes in the gas composition.

The second method requires apparatus that is more troublesome to provide, but it is continuous in its operation and therefore more satisfactory when once set up. It consists of a small water-sealed plunger pump and a receiving and pressure-equalizing tank, connected up as represented in Fig. 2. The pump may be belt-driven, as indicated by the presence of the pulley, or operated by any other convenient means. It should be of such a size and operated at such a speed as to be able to give a theoretical displacement of about ½ cubic foot per minute. The actual delivery of gas will be considerably less than this on account of slippage, but the pump should be driven fast enough to deliver not less than a cubic foot of gas to the calorimeter every five minutes. The equalizing tank is provided with a waste outlet which can be adjusted to take away any excess of gas delivered by the pump.

The motion of the pump plunger causes the column of water to reciprocate and this really forms the pump for the gas. The check valves in the inlet and discharge pipes operate in the ordinary way. The water plunger, of course, is air and gas tight at the pressures that would occur in use. The gas pumped is therefore free from any contamination due to leaks at the pump. The constant contact with the water in the pump and the receiving tank keeps the passing gas saturated. The apparatus, therefore, contains no inherent source of error. Its operation is very simple after it is once installed, and has proven very satisfactory.

Well Managed Diesel Engine Plant

BY S. KIRLIN

The writer recently visited the power plant of the Prairie Pebble Phosphate Company, which is located near Mulberry, Fla., and now contains eight pairs of Diesel oil engines having a rated capacity of 450 horsepower per pair, with a possible overload ability of 500 horsepower. It is said to be the largest plant in the country in which Diesel engines are used exclusively. Each pair of engines is coupled to a 300-kilowatt three-phase 60-cycle alternator, located between the two engines. On each side of the generator is a coupling by means of which either engine can be disconnected, leaving the generator to be operated at half load by the other one at any time it may become necessary to make repairs or adjustments to either of the engines.

Arrangements are provided for easily testing, by means of a water rheostat, the power that any of the engines is capable of developing. In a small brick building adjoining the power house is a switch panel which contains eight three-pole switches which are connected respectively to the main terminals of the eight generators. From these switches the current can be passed through measuring instruments to the water rheostat, which consists of a tank in which the plates connected to each leg of the circuit can be immersed, means being provided for regulating the depth of immersion in order to regulate the load on the generator. This convenient outfit for testing makes it possible to keep each engine up to its highest point of efficiency, and in case any one of the units shows a tendency to carry less than its share of the load, it is an easy matter to prove which engine is causing the trouble.

A fault which has been frequently charged against the Diesel engine is its tendency to break its crank shaft. In order to guard against any distortion which might lead to such damage, the shaft bearings in this plant are kept lined up accurately. All of the bearings are carefully checked for alinement at frequent intervals and any unequal wear is taken up promptly before there is any danger of its going far enough to weaken the shaft. The station has been in operation for about four years and up to this time there has never been a broken shaft or even a hot box on any of the engines.

In order to get a better distribution of oil over the surfaces of the piston and cylinder the chief engineer of the plant removed the pistons from one of the engines and had an extra groove turned in the lower end of each about 4 inches below the point where the gudgeon pin passes through. A snap ring was fitted in this groove to act as a wiper and to retain the oil which would otherwise

OPERATION DATA OF PLANT

Week ended	April 7	April 14	April 21	April 28
Total kilowatt-hours	292,900	298,500	284,700	294,600
Fuel oil, gallons	25,746	22,218*	23,982	24,528
Fuel oil, gallons per 100 kilowatt-hours	8.82	7.44*	8.42	8.33
Engine oil, gallons	369	148	399	447
Dynamo oil, gallons	1⅛	1¼	1⅛	1¼
Cost of fuel oil	$551.70	$608.35*	$531.90	$525.60
Cost of lubricating oils	100.33	40.57	108.43	121.51
Supplies and repairs	4.48	41.76	26.35	44.32
Operating labor	360.05	372.09	350.55	335.25
Total weekly expense	$1,016.56	$1,062.77	$1,017.23	$1,026.68

Aggregate kilowatt-hours for the four weeks 1,169,800
Aggregate expenses for the four weeks $4,123.24
Cost of operation per kilowatt-hour, average ..... 3.525 mills

*The fuel oil used during this week was of better quality than the regular crude oil and cost $1.15 per barrel of 42 gallons as against 90 cents for the latter.

trickle down out of the end of the cylinder. This expedient resulted in such a decided improvement in the condition of the pistons and rings that all of the others have since been fitted up in the same manner. In the four years that this plant has been in operation it has not been necessary to bore out any of the cylinders.

The company operates a trolley line 12 miles long, which connects with all of its various mines, the ore being hauled to the washers and drying plants with electric locomotives. In addition to furnishing current for operating this trolley system the power plant also furnishes power for operating all of the motors in the washers, drying plants, and driving a large number of centrifugal pumps in the various mines.

Preparation is now under way for doubling the capacity of the power plant by the addition of eight pairs of engines and eight generators of the same size and arrangement as the units now in service. The new units will be set in line with the present ones by extending one end of the power house.

Through the courtesy of James W. East, chief engineer of the plant, the accompanying operation data are presented.

Test of a Blast Furnace Gas Engine

A test run of 1¼ hours was recently made on a twin-tandem Snow gas engine running on blast-furnace gas at the Youngstown works of the Carnegie Steel Company, with the results stated in the accompanying table. The cylinders are 42 inches bore and the stroke is 60 inches. The speed of engine was 83⅓ revolutions per minute; the piston speed, therefore, was 833 feet per minute.

SUMMARY OF TEST RESULTS

Full load rating, kilowatts	2,200
Average load, kilowatts	2,190
Average load, brake horsepower	3,090
Cubic feet of gas per hour	291,080
Bt.u. per cubic foot of gas	86.62
B.t.u. per hour in the gas	25,213,350
B.t.u. per kilowatt-hour	11,513
B.t.u. per brake horsepower-hour	8,160
Efficiency of generator	95%
Brake thermal efficiency	31.2%
Over-all thermal efficiency in power delivered at switchboard	29.6%

CORRESPONDENCE

Vapor Lock in a Fuel Oil Feed Pipe

A small three-cylinder stationary engine running on benzol was supplied with fuel under pressure because it was inconvenient to put the benzol tank high enough up to obtain gravity feed to the carbureter. It was found that the engine, which was hand regulated, would be "starved" of fuel and run spasmodically and often stop if it was attempted to run it slowly or with little load. If, on the other hand, a considerable load was being carried and the throttle was opened out, the flow of benzol to the carbureter was uninterrupted. After much head-scratching on the part of the staff it was discovered that the cause of starvation was that the feed pipe had been carried over the top of the engine exhaust pipe on its way to the carbureter, presumably in order to assist vaporization by heating the fuel oil, and that the benzol had vaporized in the loop and the vapor pressure had caused a lock when the flow was only what was required for light running. If on load, the flow was too rapid for this amount of vaporization to take place. The feed pipe was shortened and altered to a gradual slope up from the tank to the carbureter and no further trouble was experienced.

JOHN S. LEESE.

Manchester, Eng.

The Heavy Oil Engine

I have read with more than usual interest the editorial on "The Oil Engine" in the issue of POWER for June 6. It is quite evident from a consideration of the recent papers presented before engineering societies that the development of the Diesel type of oil engine is progressing rapidly in Europe, while in this country it is so little used as to be practically unknown. It has been said that the reason why America has more or less ignored the Diesel engine was that coal was so cheap that the Diesel could not compete with the steam engine, and that gasolene was so cheap that there was no market for the oil engine. It seems to me that it would be better to say that their general use in this country has been prohibited more by their high initial cost per horsepower installed and the high cost of maintenance which has been reported from the first installations than anything else.

There is hardly any doubt that in certain fields where its manifest advantages more than compensate for its extra expenses, the Diesel engine will have much success, especially in the larger horsepowers, but for general industrial use in small horsepowers it is hardly possible that it will be widely used, because the gain in fuel economy does not offset the charges on the initial outlay and the later maintenance charges.

It seems that what we need very much in America is an oil engine which operates with only a fraction of the compression of a Diesel and atomizes the fuel mechanically, that is, without a compressor. Of course, in such an event the ignition would have to be effected by a hot bulb or some similar device. There are on the market several oil engines working with compressions of from 75 pounds to 150 pounds and there seems to be no good reason why the compression cannot be raised to a higher point and still avoid the use of such auxiliaries as the compressor.

I understand that an engine has been recently designed to work with a compression considerably more than that of the ordinary oil engine but still only about one-third of the Diesel compression. There is every reason to believe that such an engine will have a higher fuel efficiency than the ordinary oil engine and, in fact, will probably closely approach Diesel fuel economy. Apparently it will fill the gap which has existed between the high-compression oil engines represented by the Diesel and the low-compression oil engines as represented by the vast majority.

JOHN S. NICHOLL.

Sharon, Mass.

[Engines working with compressions of from 150 to 300 pounds pressure have been built in this country several years, but mechanical atomization of the fuel appears to have been found impractical. It has been tried faithfully and discarded in favor of compressed air.

Any modification which entails the use of an auxiliary device for igniting the charge would be a step backward; as we pointed out editorially in the June 13 issue, the absence of ignition devices is undoubtedly one of the chief factors in the success of the Diesel engine.—EDITOR.]

Trouble from a Long Exhaust Pipe

The owner of a feed store bought a 3-horsepower gas engine which had been used for about one year, for the purpose of running an elevator. The man who sold it helped to set it up, but when everything was apparently ready, the engine failed to respond. Everything was gone over very carefully and the seller said he could not see why it would not run, as it had "worked fine" on the previous job. I was called in to see what I could do and after a couple of attempts to start I concluded it was another case of a clogged exhaust pipe. Upon disconnecting the pipe from the exhaust outlet the engine ran all right, but I was unable to find any obstruction in the exhaust pipe and as there were no elbows or turns in it, it began to look mysterious. The pipe extended straight up from the engine through the second story and on through the roof about two feet. We then concluded that the length of the pipe was too great for the engine, and made connections so as to run it out of the side of the room; then the engine ran all right.

Can anybody explain why the long exhaust pipe prevented the engine from running?

H. H. DELBERT.

Titusville, Penn.

Readers with Something to Say

Practical information from the man on the job. A letter good enough to print here will be paid for. Ideas, not mere words wanted

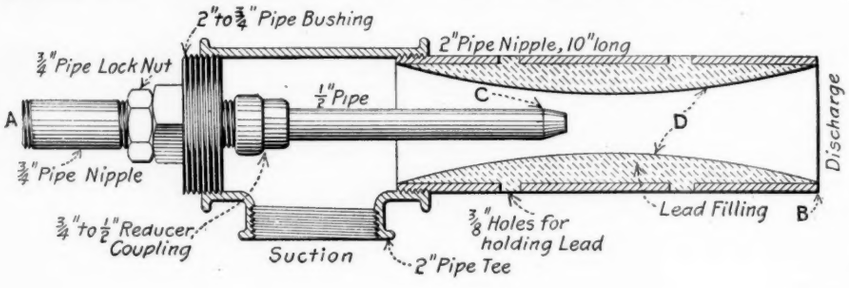
Homemade Water Ejector

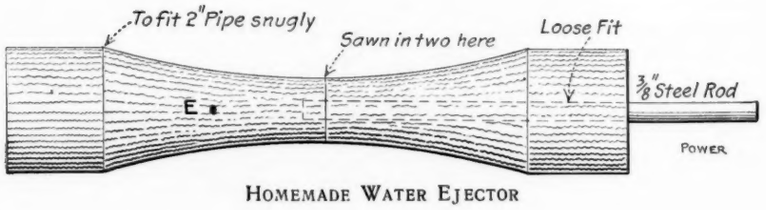
An erector who was sent about 1200 miles from the factory to erect and start a new 500-horsepower Corliss engine, laid out the foundation excavation carefully and pushed the digging until he struck water, then the work went forward with much less speed.

He tried small tin waterspout hand pumps, but two men working them day and night made no headway. Then he rented a diaphragm wrecking pump from the city water company, but still the water stood practically stationary at about 3 feet below the floor level, and he had to go 10 feet below the floor.

As this was a new plant it was impossible to get steam; even the gasolene engines, which had been used for mixing concrete, had been moved away. Finally the erector remembered having read of a water siphon being made out of pipe fittings to operate with water pressure. He had an ample water supply right in the engine room from the city pumping plant and under a good pressure, so he went to the only steamfitter in that town and told him in a general way what he wanted. The fitter seemed to know all about such things and promised to have the ejector ready at seven o'clock the next morning.

In Fig. 1 is shown the fittings which formed part of this ejector. A piece of 1-inch hose was coupled on at *A*. At *B* a 2-inch elbow was screwed on, pointing upward, and a piece of 2-inch pipe about 7 feet long was bent to form a long radius elbow at the upper end and all were lowered into the water and the city pressure was turned on, but no water was ejected. The hose was shortened as much as possible, but this did not improve matters. By tapping the side of the pipe with a light hammer it was found that the water in the pipe came nearly to the discharge point.





HOMEMADE WATER EJECTOR

He next determined to line the discharge nipple with lead, as shown at *D*, using the wooden core made as shown at *E*. Care was taken to file the end of the jet nozzle *C*. The ejector was then put together and tried with satisfactory results. A solid stream of water was ejected from the 2-inch pipe with considerable force, and the water level rapidly fell in the excavation. The ejector was kept in a small sump about 6 inches from the bottom. The whole secret lay in knowing how to make the discharge nipple, which evidently the steamfitter did not understand, for one of the funny incidents of this experience was that he went to see how it was working and talked most enthusiastically about it. When told that it would not work, he insisted that it must have been because it was not connected up properly.

F. W. SALMON.

Burlington, Ia.

Carelessness in the Power Plant

The best of engineers will become a little neglectful at times, and some are naturally careless all the time.

On one occasion, for some reason, a hard-pine board about 6 feet long, 2 inches thick and 8 inches wide had been used in a boiler on top of the tubes. The man who cleaned this boiler evidently forgot that he had used the board and had put in the manhead without removing it.

When the boiler was opened for cleaning the next time the board was found in a black mass on the bottom of the boiler. It had caused no bother but pieces of it might have got into some pipe and caused serious trouble.

Another incident which I recall was that of making a connection on a header. The stop valves on each boiler were closed, but a 2-inch bleeder for the header was connected to the back end of the boilers, and the valves in it were forgotten. The connection was made on the header with these valves open. No one was hurt, but if one of the check valves had failed to close or something had gotten under it someone might have been scalded.

Another dangerous practice is that of going into a boiler with the blowoff valve open when the blowoff pipe is also connected to another boiler that is under pressure. A vertical check valve is not a bad thing to have in the blowoff pipe, but the great trouble with such safety devices is that too much dependence will be put upon them.

E. V. CHAPMAN.

Decatur, Ill.

Dangerous Water Column Connection

A return-tubular boiler of ordinary dimensions was purchased from a certain boiler manufacturer who desired to send a man out from the shop to superintend the setting up and starting of the boiler. The buyer, however, protested, as his experience in handling boilers extended over many years and he knew that his own force would not

have the slightest difficulty in installing and getting the boiler into operation.

Nothing was heard from the purchaser for about two weeks, when he appeared at the boiler works in an exceedingly bad frame of mind. He proceeded to abuse the firm and its work and said that the material used in his boiler was perfectly worthless, as the plate over the fire bed softened and the seam had opened, and that they narrowly escaped serious trouble.

The boilermaker protested that the material was of the best and that low water evidently caused the trouble. Of course, no admissions were made that such a thing could be possible.

To settle the controversy a trip to the plant was made, and an examination of the boiler confirmed the boilermaker's opinion that the water in the boiler had been low. The operator still insisted, however, that the gage glass had always shown plenty of water.

"Where is the top connection?" asked the boilermaker.

"Oh, you don't need one," was the answer; "we never connected it up."

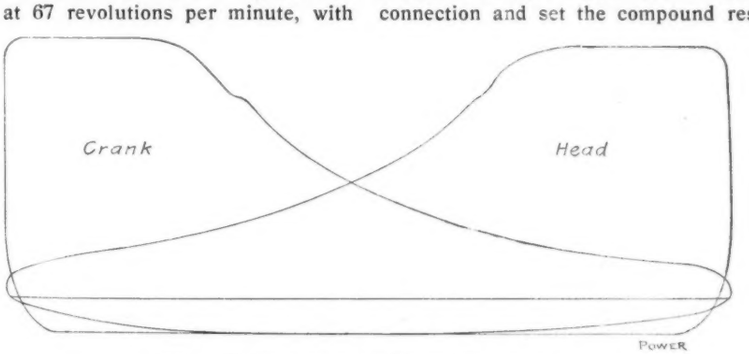
So the fireman was right; there was plenty of water in the glass.

EDWARD T. BINNS.

Philadelphia, Penn.

Wants Diagrams Explained

The accompanying diagram was taken from a 20x48-inch Corliss engine, running at 67 revolutions per minute, with



WHAT IS FAULTY WITH THESE DIAGRAMS?

boiler pressure of 70 pounds and a vacuum of 23 inches.

I want to know why the expansion line does not come down below the atmospheric line. It will be noted that the release and exhaust line turn up instead of down. The engine runs noncondensing, without pounding, but pounds very badly when running condensing.

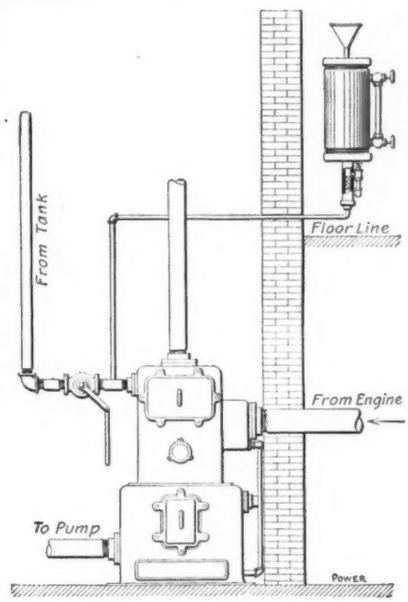
C. A. POARCH.

Petersburg, Va.

It is estimated by the Geological Survey of Tennessee that there is yet to be obtained from the Tennessee, Cumberland, Green and Mississippi rivers 1,054,000 of undeveloped horsepower. Surely this is worth looking after.

Homemade Compound Feeder

All the methods I have read about for feeding compound to boilers are unlike the method I use.



COMPOUND FEEDING TANK

The feed-water supply tank is 30 feet above the heater. I tapped the pipe coming from the heater at a point 3 inches from the heater for a ½-inch connection and set the compound reservoir 4 feet above the heater, the pressure in which is not enough to effect the feeding of the compound.

The accompanying sketch shows my method of feeding the compound to the boiler from a homemade sight-feed compound feeder. The cylinder is made from a 10-inch pipe 2 feet long, capped at each end and tapped for a gage glass. The bottom cap is tapped for a 1½ pipe, which is 10 inches long For a distance of 4 inches through the center the pipe is filled with babbitt metal. The pipe is then tapped above and below the metal for the sight-feed connections for which old lubricator parts are used.

J. W. DICKSON.

Memphis, Tenn.

Suspending Horizontal Tubular Boilers by Means of Hangers

A common practice with horizontal return-tubular boilers is to support them by means of lugs resting on rollers, which in turn rest upon iron plates imbedded in the brick setting. This practice has proved most satisfactory, but the question which constantly arises in my mind is why the practice of suspending boilers by means of hangers from I-bars is not more generally adopted, such as is carried out in setting water-tube boilers.

Such a method is feasible if I-beams are run transversely across the boiler overhead and are supported by steel columns protected from the heat of the furnace by the brickwork. This would bring all the weight on the foundation of the setting and no strains would be brought to bear upon the brickwork by the boiler. By this method the columns would support the brickwork and the brickwork would give the columns lateral support.

In some instances, I have seen the I-beams exposed to the air of the boiler room or built into the brickwork so that the outside surface came flush with the brick setting. This method, of course, prevents the column from ever becoming overheated.

It does not seem advisable to build the columns solidly into the masonry, especially in the case of two boilers or more being set in batteries. In such a case, the columns passing through the brickwork forming the setting between the two boilers would be liable to become overheated and the walls would, therefore, be warped and cracked.

A study of this method of boiler setting reveals three defects which may easily creep in if they are not guarded against. The first is that the I-beams may not be sufficiently rigid or of a strength great enough to support the weight that might be brought to bear upon them; second, the supporting columns themselves may be of a strength or stiffness insufficient to withstand the strain put upon them, and third, the means for preventing overheating may have been overlooked entirely or the setting of such design as to render it incapable of bringing about the proper results.

In cases where boilers are set in batteries of more than two, it will be necessary to have center supporting columns resting on the foundation. In order that this may be kept cool a space should be built around it in the brickwork.

Ventilation could easily be secured by allowing the space at the top to remain open and space made at the bottom of the column to form a sort of air duct, so that there will be a circulation

of cool air up through the air space surrounding the column.

Of course, the size and shape of the supporting columns and the size and weight of the I-beams would necessarily have to be calculated in each instance, so that they would be of sufficient strength to support the weight which would come upon them. This would require calculation by someone familiar with determining the strains, bending moment, etc., of iron and steel structural work.

L. HOLDER.

OUIMET, ONT., CAN.

Side Play in Crank Pin Brasses

A practice in engine design which proves to be troublesome is shown in Fig. 1. In one instance ¼ inch was al-

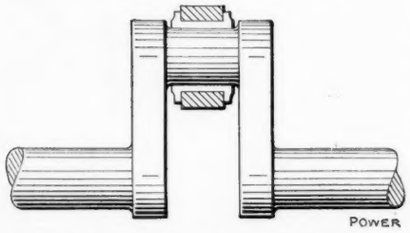


FIG. 1. SIDE PLAY ON CRANK PIN

lowed on each side of the crank bearing for lateral play. This idea did not come from the engine room, as many engineers have so faced off the pin of a crank engine as to bring it closer to the sides of the rod and eliminate the side slap.

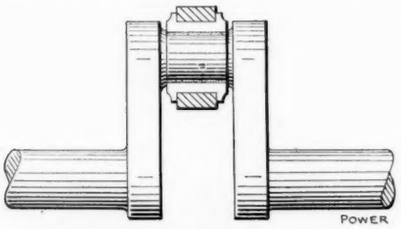


FIG. 2. FILED CRANK PIN

Many times I have faced off the sides of a crank bearing and put on segments to fill up the space brought on by wear. But here is an engine built with side play in the crank-pin brasses which will cause trouble.

In Fig. 2 is shown how I was compelled to file the pin and fit the brasses.

C. R. MCGAHEY.

Baltimore, Md.

Bagged Water Tubes

When tubes in water-tube boilers become bagged it is usually but a short time until they leak and need replacing. Bagged tubes are mostly found in the rows nearest the fire, and may be easily reached from the furnace. The life of the tubes may be prolonged by driving the bags back into place, as is done with the fire sheets of boiler shells.

My method is to plug the ends of the affected tubes to prevent air circulating through them while they are being heated. The heating is done with a gasolene blow torch, which brings the metal to a red heat in a short time. The bag is then driven back with a hand hammer, working toward the center from the outer edges of the bag until the tube is round. A tube repaired in this manner will last as long as those which were never bagged.

P. L. WERNER.

McKeesport, Penn.

Scale Cause of Low Vacuum

The incident described herewith relates to an experience I had with a low-pressure turbine. For two months the new plant did well, barring minor troubles that were easily located. Then the 29-inch vacuum began to drop from day to day, and in two weeks the turbine was running with from 22 to 24 inches of vacuum.

All connections were carefully gone over and painted, the dry and wet air pumps were thoroughly overhauled, the condenser taken apart and examined, and the atmospheric valve inspected, but there was no increase in the vacuum.

On starting up one Monday morning the vacuum failed to build up and it was a case of having to remedy the trouble. Chain blocks were rigged up, the upper half of the casing was lifted and the trouble was located in the water seals on each end of the turbine, which had become incrusted with such a hard scale deposit that it required light chisels to remove it. During the trouble the gages on each water seal had registered correctly, and as the plant had been in operation but a short time, it was puzzling to locate the trouble as the imperfect water seals were not suspected.

This same trouble is sure to happen again, but profiting by past experience, there will not be two weeks' work and worry. The water used is principally from a lead mine.

W. TURNER.

Doe Run, Mo.

Indicator Cord Lock Knot

It frequently happens when indicating an engine that the operator finds the drum of the indicator striking at both ends of its travel. This may occur at a time when the proper conditions have arrived for taking a diagram.

The accompanying illustrations show a knot which can be conveniently loosened and adjusted. A slip knot is shown at *D*. The loop *B* may be attached to the indicator hook and by adjusting the end *A* the loop *B* may be made any desirable length.

The lock knot, shown at *E*, serves to lock the loop *B* after it has been adjusted. *F* shows the knot ready for action.

In case the cord has stretched or shrunk, pull out the first loop and make

Fig. 1

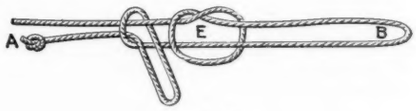


Fig. 2

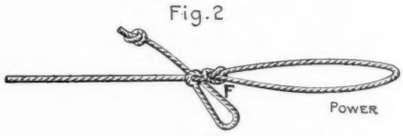


Fig. 3

STAGES OF MAKING LOCK KNOT

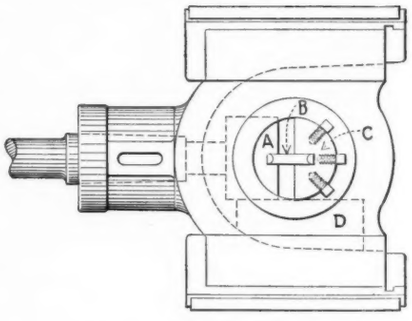
the proper adjustment to the loop *B*, after which the lock knot can be tied again.

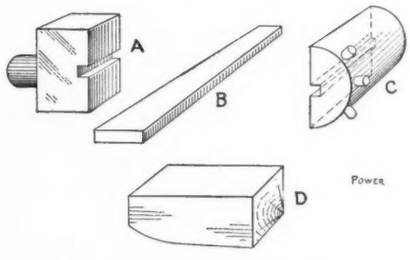
CHARLES H. CROOM.

Detroit, Mich.

Device for Separating Piston Rod from Crosshead

The accompanying sketch illustrates a method used for removing the piston rod of the slot-and-key type from a crosshead. The wristpin is removed and replaced by the block *A*, key *B* and block *C*, all resting on the wooden block *D*, to keep in position. The studs are tapped into the





DETAILS OF SEPARATING DEVICE

block *C* to hold it in position. Very little trouble is experienced when the wedge *B* is driven "home" in starting a rod.

E. S. HODGES.

Medicine Hat, Can.

Questions Before the House

Comment, criticism, suggestions and debate upon various articles, letters and editorials which have appeared in previous issues

Piston Rings

In the June 20 issue of POWER, C. R. McGahey gives his ideas of keeping piston rings tight. It looks very much from the article as if Mr. McGahey is laboring under the delusion that there is only one kind of a piston and that must

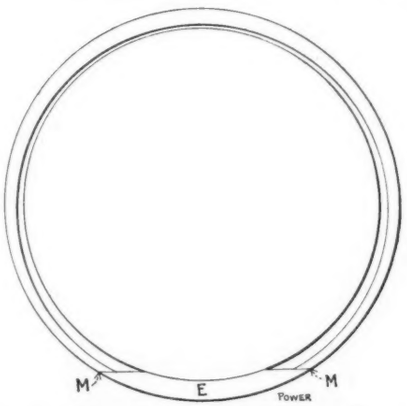


FIG. 1. OLD METHOD OF MAKING TIGHT PISTON

be a solid one. Regarding Fig. 1 of his article, which is reproduced herewith, I never saw a more elaborate affair for scoring up a cylinder at the points marked *M*.

Again, the cost of the piece *E* would almost equal the cost of a new ring, to say nothing of the careful measurements and fitting that would be necessary to have the angles of the bull ring and piston ring coincide to form a good joint.

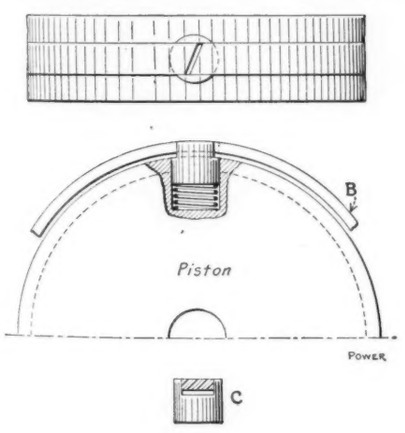


FIG. 2. PLUG AND SPRING METHOD

Regarding Fig. 2, also reproduced here, which shows a heavy spring under the bronze plug, the increased surface and friction of the plug rubbing against the walls of the cylinder would certainly put a groove along the cylinder. And, again, the mere action of bolting up the follower plate would cause it to bind unless it was a very loose fit and in that case it would be useless.

I might say that the joint which I showed in a previous letter and which Mr. McGahey, without giving any reason, says is a poor apology, is in use for the severest service that a ring can be put to, namely, on stamp heads for crushing copper ore. The dimensions of these are: Cylinder diameter, 24 inches; stroke, 26 inches. They work under 130 pounds steam pressure and at the rate of 118 strokes per minute.

G. H. HANDLEY.

Newburgh, N. Y.

Air Compressor Running Under

In the August 1 issue the question is asked if there is any reason for running an air compressor under. The answer states that there is none, and if the question refers to a straight-line, steam-driven machine, it is correct, for the air piston pulls directly on the steam piston while the flywheel serves to carry the crank over the center. There are, however, a large number of compressors driven by other power than a steam piston; these include motors geared direct or belt driven from some source. Many of these are designed with very light crosshead guides which would not allow of a very heavy pull, and the makers of these machines usually advise running them under so that the pull of the connecting rod will come in a downward direction on the frame of the machine.

G. H. KIMBALL.

East Dedham, Mass.

A question was asked in the August issue regarding the direction of compressor rotation. In air compressors where the air cylinders are directly behind the steam cylinders, running the compressor under brings the pressure of the crosshead on the lower guide; running it over brings the pressure on the upper guide, the tendency being to lift the machine from the foundation. This is directly opposite to regular engine practice, and is due to the power being exerted in a different way, which may be readily seen by following the action of steam and air in their respective cylinders. It would seem then that there is a reason for running a compressor under.

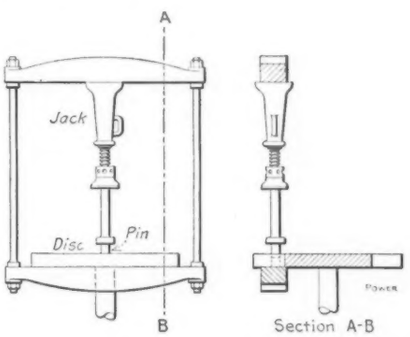
DAVID BILLSON.

North Chelmsford, Mass.

Putting in Crank Pins

B. W. Robinson's article, "Pins in Loose Crank Pins," in the July 18 issue, brings to mind the difficulty of putting in new crank pins in isolated places.

By using a common jack screw and making a frame to clamp on the disk,



JACK AND FRAME FOR FORCING IN PIN

as shown in the accompanying figure, the pin may be pushed in tight and with ease.

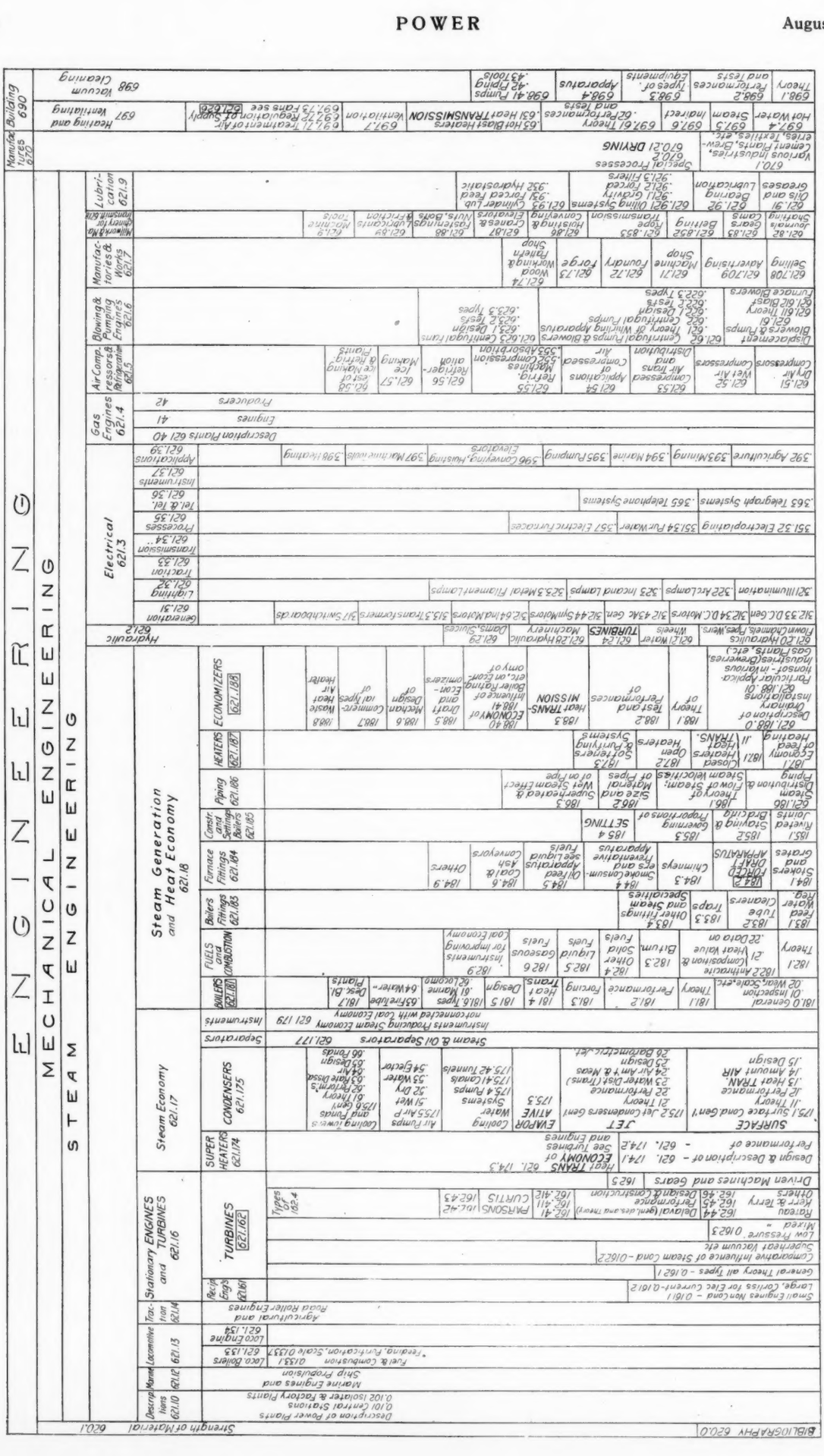
As may be seen, if the frame is proportionately constructed, the pin may be put in without removing the crank shaft from its bearings.

LLOYD V. BEETS.

Nashville, Tenn.

Filing Engineering Articles

Mr. Andrews' method of filing engineering articles, as set forth in his letter in the June 27 issue, is thorough as regards the method of making out duplicate index cards to be filed alphabetically under all possible headings, but thorough cross indexing is laborious and in a private file can to a large extent be obviated by adopting a suitable system of classification. I know of other instances where the scheme of pasting clippings in a loose-leaf binder is used, but in a busy office where time is valuable and a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MANNER OF INDEXING ARTICLES ACCORDING TO MODIFICATION OF THE DEWEY SYSTEM

number of engineers mark clippings, pamphlets, catalogs, etc., for filing as they come up, the use of a book has obvious objections.

The filing of clippings from the technical magazines, papers before engineering societies, correspondence containing technical data, blueprints, tables, etc., reports of tests, drawings and similar matter cannot be wholly relegated to a clerk or inexperienced office assistant, since such matters cannot be filed in proper shape without first being read through and the contents digested. An article on battleships, for instance, may have a very excellent discussion of some phase of turbine operation and design, so that its proper place for the office in question might be under that heading.

Again, not only should the clipping or other literature be given its disposition in the file, as determined by the most valuable information it contains regardless of its title, but, furthermore, its position in the file should be such that it will be among the material on similar subjects. For instance, an article on stokers should properly be placed among material on combustion, although "Stokers" may begin with an "S," while "Combustion" begins with a "C." Where a card-indexing system is used, cards having the same index initial will be together, while the information itself will generally be in some sort of chronological order. The clippings desired may thus be scattered through half a dozen bulky books. The trouble with scrap books is that they do not permit indefinite expansion at any desired point.

Some years ago the University of Illinois published in a bulletin an extension of the Dewey decimal system of classification, as applied to engineering industries, by L. P. Breckenridge and G. A. Goodenough, of that school. In the accompanying chart this system has been adopted, with considerable extensions in some parts and cutting down in others, to meet the peculiar needs of the work in this office.

Take the subheading "Steam Generation and Heat Economy" 621.18, as an example; this is under "Steam Engineering" 621.1, which in turn is under "Mechanical Engineering" 621, and the general heading "Engineering" 620. Under "Steam Generation and Heat Economy" come boilers, fuel and combustion, boiler fittings, furnace fittings, economizers, etc. These subdivisions are still further extended by adding another figure to the decimal so that a great increase in the amount of material under any subheading is easily subdivided and classified.

A chart of this kind gives a comprehensive view of the actual filing system. At a glance, the general heading under which a clipping should be placed is determined and then the proper subheading. Having placed the proper number on the clipping, the remainder of the work is purely mechanical. A filing clerk or boy places it in its proper position numerically. The simplest form of file to use is one made up of ordinary manila jackets, such as are used in the common vertical files for correspondence, the individual jackets being given numbers corresponding generally to the subheadings on the fourth line of the chart. When a jacket becomes too bulky, its contents are easily divided and put into two or more new jackets which are given appropriate numbers.

When information on some subject is wanted from the file the chart makes reference very simple. Suppose, for instance, data are wanted on tests of centrifugal fans. The decimal number for centrifugal-fan tests is 621.623.2, under the heading "Blowing and Pumping Engines" 621.6. Assume that the file is of such size that a folder is numbered 621.623; then in looking up the number 621.623.2 on tests, the whole jacket would, of course, be taken out and articles which had been filed under "Design" 621.623.1 and also under "Types" 621.-623.3 (and other subheadings that have been included in the classification) would be turned up at the same time. Any material on tests of fans, although in an article on some related subjects, would thus be brought to light. Cross indexing is by this means practically eliminated, and the little required is easily provided by filing a sheet of paper, showing the title and number of any article filed elsewhere which may contain information on the subject in question.

PAUL A. BANCEL.

New York City.

Going Over the Chief's Head

The editorial on the above subject in the July 25 issue put the matter in a very good light, but there are times when it becomes necessary to go higher. However, I do not favor trying it unless there is something of great importance at stake, as the organization of any plant should center around its head.

Once while in charge of a power plant I was unable to agree with the master mechanic on certain matters and gave notice of leaving. Upon being asked as to why I wished to leave, this trouble came out and the treasurer of the company said that I should have come to him about the matter. This, however, would have caused more trouble; the master mechanic would have distrusted my intentions, and the friction would have been increased instead of lessened. I had tried to support him in his work, and when I found that it was impossible, I left the employ of the company.

It is firms of this sort which encourage their subordinate employees to come to them with stories about what is going on inside instead of depending for their information upon the department heads, and with the firm in question this has gone on to such an extent that the general organization of their factory is in bad condition as regards efficiency.

If such practices work out in this way in a factory, why not in the power plant? The chief engineer who cannot deal squarely with his men is not the proper man for the place because he is a detriment to the organization, as it is plain that the men will distrust him when he promises anything better. Here is an illustration of a man who was assistant in a mill plant and who, wishing a raise in wages, first went to the chief engineer, who, after a few days told him that he had consulted the superintendent and nothing could be done. Then the assistant spoke to the treasurer, who made arrangements for him to get the increase. In one or two other instances this same procedure succeeded. The main result was gained, but the assistant did not feel that his immediate superior valued him highly enough to even try to give him more, and it was left for the higher official, who was not in a position to judge of his qualifications intelligently, to give him what he asked. In the same plant one of the fireman who had proved his worth over any man they had had in that capacity for some time, asked for a slight advance in wages. He did not get it; he did not try to go around his chief, and as he was disgusted with the treatment he had received, he left shortly after and his loss was felt for some time to come.

In a case like this, where the chief is so lacking in the moral requisites that go to make up a good man, and who showed no vexation when a matter was ordered over his head that should have been attended to by him, it is permissible to do as the assistant did.

From the foregoing it is apparent that any man in charge of a power plant, to succeed, must have such control over his assistants that they will not go over his head; neither will they try to do so if he uses them fairly. If any do, without going to him first, they should be disciplined, and any manager who encourages this practice is only making trouble for himself.

G. H. KIMBALL.

East Dedham, Mass.

Performance at Redondo Plant

Since 1908, POWER readers have waited patiently for a report of the individual boiler tests made at the Redondo, Cal., plant of the Pacific Light and Power Company, closely allied with the official test of the complete station.

POWER itself, in October, 1909, page 663, commenting upon a sixteen months' record at the plant, concluded with remarks that exhibit the united opinion of many of its readers, stating, "No in-

formation is as yet available as to the separate efficiencies of the boilers and engines, and this is looked for with unabated interest." We are still looking, still waiting.

Mr. Brian, then chief engineer for the company, and one of the "favored few" to see a report of these tests, gives us the following information: Sixty-one tests were made on boiler No. 6, equipped with style "D" Leahy rear-end burner, and Peabody's patent fuel-oil burning furnace, the same as used during the sixteen months' operating record published in POWER. The result of these tests gave an efficiency of approximately 86 per cent., the highest ever obtained under like conditions, and constituting a record.

With this to "excite us," is it any wonder that we are anxiously waiting?

In POWER for May 9, 1911, we are accorded a synopsis of a series of seven tests on one of the boilers, made in the present year, but with different type of burner and furnace from that mentioned above; this test states an average efficiency of 80.47 per cent. Why does this supersede in print the original test, especially when the efficiency obtained is lower?

Boiler efficiency usually interprets generating economy; POWER's published figures in 1909, attested by officials interested in the plant, give 235.64 kilowatt-hours per barrel of oil in the test of the complete plant, and 220.59 kilowatt-hours per barrel of oil as an average for actual operation for sixteen consecutive months. No public record has been furnished of output per barrel of oil during the early months of the current year coinciding with the period of the test mentioned; Mr. Brian states that for the month of April this approximates 207 kilowatt-hours, average.

With last week's full description of the enlargement that has recently been made of Redondo, POWER's files stand complete with this plant, save for the instance noted, and what would reasonably appear to be one of the most interesting and instructive items connected with the work.

LEON ALIAS.

Los Angeles, Cal.

Isolated Plant Management

I fail to see wherein the central station should bother the engineer who has a half-way decent plant and is operating it creditably. It is every engineer's duty to know what his plant is doing, and if he has not the proper facilities he can by the exercise of good judgment make a creditable showing if he does not get tired and allow things to go their own way.

His boilers should be kept clean inside as well as outside, the combustion chambers, as well as tubes must be scraped frequently, and he should locate all the leaky joints in the boiler settings and plug them with asbestos and filling outside with cement; prevent all leaks in flues and clean out doors that are admitting air; keep the feed regular, and have a sane method of firing. No set rule can be made for this work as the conditions vary so much. The feed pumps should be closely watched to know that the piston and rod packings are tight and the valves are in good condition; that the pumps (especially if they are duplex pumps) do not short stroke, and it must be remembered that if a pump short strokes it takes the same amount of steam to operate it as though it ran full stroke, although it is pumping an amount of water proportionately short of the amount it should discharge were it making its proper length of stroke. Consequently to pump its proper amount it must make more strokes; this not only takes more steam than it should, but uses more oil and wears the shoulders in the cylinders by not traveling over the bore of the cylinder into the counterbore. In a duplex pump this short stroking can easily be remedied by packing all the rods and water pistons carefully and giving a proper amount of lost motion to the valve gear. More lost motion makes the stroke longer and less lost motion, of course, shortens the pump stroke.

The temperature of the feed water should be carefully looked after. The engines should be taken care of and the valves kept correctly adjusted and examined frequently for leaks. The pistons should be examined at least every six months for correct adjustment as well as for tightness of rings and inspection made of cylinder walls.

If these matters are properly attended to, and the machine well lubricated while in service, there is very little chance for trouble and no danger of the plant being superseded by outside service. A log should be kept of the plant so that the engineer as well as the management may know the cost of the service per kilowatt- or horsepower-hour. This log should also include the cost of coal, oil, waste, repairs, help, interest, etc.; in other words, the total cost divided by the unit output should be known or easily ascertainable on short notice.

WILLIAM S. TROFATTER.

Somerville, Mass.

The Cornell System

In the July 4 issue of POWER an article entitled "The Cornell Economizer" attracted my attention. As some of the statements contained in it are the same as those made by all manufacturers of steam-jet blowers used under boilers, I fail to see where the Cornell system improves over the ordinary steam blower, as this system is nothing more than a steam blower. The claim that by using it larger quantities of heated air are injected under the grate is the identical claim made by all manufacturers. There never was any doubt in the minds of practical engineers but that a boiler rating could be increased by applying a steam-jet blower or a fan to force air into the ashpit. But the cost of using a steam jet is generally taken to be from 7½ to 10 per cent. of the steam generated, and when this is subtracted from the increased evaporation of the boiler it leaves a narrow margin for economy. The cost of installing a steam jet is very small as any practical engineer can make and install one for $10, but the cost of installing a Cornell economizer should put any manufacturer on his guard if the price is as is claimed, $10 per boiler horsepower, builders' rating.

For instance, for a 150-horsepower boiler it would cost $1500, or more than the boiler itself. As the writer of the article did not explain this, I think it well to do so. At that rate it looks like a stiff price for a steam blower, and the system is nothing but a steam blower. The article says steam can be decomposed in cast-iron retorts, but does not say at what temperature. I claim that the Cornell system does not dissociate it, and that if steam is decomposed by this system the temperature is above the igniting point of the gases; this being the case they will ignite back to the outlets.

Twenty odd years ago I experimented with a man who claimed that he had a patent on a method of making these gases, and in these experiments we melted the wrought-iron pipe and malleable-iron fittings in the furnace. At the melting points of these metals the inventor failed to dissociate the steam. The steam passing through the Cornell retorts is simply superheated and is not dissociated as claimed. I have heard that Doctor Paget, an Englishman, experimented with the Cornell system and was unable to prove dissociation of steam at a temperature of 4500 degrees Fahrenheit, and was not able to collect any gases resulting from dissociation. Paul J. Dashnell, of Johns Hopkins University, and William C. Day reported that this system did not dissociate steam.

One who is looking for truth should read a mechanical engineer's experience with the system on page 39 of the March 7 issue, and any engineer who is interested in the subject can make any style of steam blower on the market himself and prove to his own or his employer's satisfaction that the statements contained in this article are nothing but truth as found out years ago by practical running and mechanical engineers.

MICHAEL H. HARRINGTON.

Fall River, Mass.

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POWER

Good Work Needed on Piping

Where condensers are used the supply of cooling water is often brought into the plant through long pipes laid for the greater part of their length underground. Cast-iron pipe with "bell and spigot" ends made tight by lead and oakum joints is generally used because the cost of pipe with this type of joint is much below that of pipe with flanged and bolted ends. To insure tight work in pipe joints of this type requires the exercise of a high grade of skill, and the work should not be done by ordinary mechanics. While under pressure and before being covered with earth, lead joints are readily inspected and easily made tight, but under suction, leakage is not so apparent, and it may become quite serious before it is suspected. In cases when leaks are known to exist it is always difficult and sometimes impossible to locate them, particularly if they are numerous and small.

In surface condensers air in the circulating water will not cause a serious inconvenience or impairment of the vacuum. It may hasten the corrosion of the tubes by supplying the oxygen necessary for their destruction, but a slight increase in the speed of the circulating pump will maintain as high a vacuum with large quantities of air in the water as will a lower speed without it. But with jet or barometric condensers free air in the water means a reduction in the vacuum that cannot be corrected by increased pump speed or a wider opening of the injection valve. In fact, either of these will make matters worse, for the degree of vacuum is as easily reduced by water as by air.

All natural water carries air in suspension, sometimes as much as five per cent. of its volume. This air is set free in the lower pressure in the condenser and when increased by a larger volume drawn in through leaking joints the difference between the theoretical vacuum that should exist at the temperature of the overflow and the vacuum that actually does exist is noticeable and annoying. With a dry-vacuum pump a high vacuum may be had by an increase in speed above that for which the pump was designed and the effect of the excess air will be felt only in the inefficiency of the pump, which will be taxed to the limit of its capacity to maintain a vacuum of, say, twenty-six inches, where twenty-eight or more is desired.

Although reduction, by one pound, of the back pressure means so much more for a turbine than for a reciprocating engine, it is a matter that should not be neglected even with the latter type of engine, and when installing a suction pipe, with any type of joint, this should be remembered. Only the conscientious exercise of skill of the highest degree will insure good results and in this class of work no part of it can possibly be too well done if permanently satisfactory operation is desired.

Handicaps of the Studious

Young engineers are constantly being urged to improve their minds and thereby their stations in life by studying the principles on which their practice is based. This advice is excellent. Increased knowledge is the one and only legitimate lever by means of which any man can lift himself from a lower position to a higher one. But when one thinks of the haphazard methods exemplified by some of the many textbooks, handbooks, etc., which are alluringly offered to the ambitious skilled worker it becomes evident that the advice to study should be accompanied by a warning to be careful as to the books that are studied.

To illustrate the kind of misinformation with which the home student is menaced: A certain reference book describes a gasolene engine working on the two-stroke cycle as a "four-cycle engine with the four cycles compressed into one revolution." Another one states that in the operation of a boiler furnace "too much excess air is uneconomical because if more oxygen is supplied than the fire can burn, it and its nitrogen take heat away from the fire up the chimney." Again: "A pressure is generated in the wires of an armature by friction due to the passage of the wires through the magnetic current." Once more: " The armature core is split up into thin sheets to keep the magnetic current from flowing in irregular paths and make it pass directly across from pole to pole."

The writers of such misleading "explanations" are not to blame; they honestly think they are helping the struggling seeker after knowledge. But the results of their unconscious blunders

are just as deplorable as though they were intentional.

Of course, the ambitious man who must do his studying at home and practically alone is unable to discriminate between accurate information and the other kind when he first strikes it, but he can avoid many false leads by merely asking for advice from the editors of appropriate engineering journals of recognized standing. We write scores of such advisory letters every year.

Single and Double Eccentrics

When both steam and exhaust valves of a Corliss engine are operated by a single eccentric, the range of cutoff is limited to less than one-half the stroke of the piston, so far as the mechanical operation of valve release is concerned. But as there is an element of time that enters into all of the valve movements the valve does not close on the instant that it is released, and indicator diagrams are often seen in which it is plain that the cutoff was not fully accomplished until the piston had made nearly, if not quite, three-quarters of the stroke.

This is much later than it should occur in the regular work except in cases of momentary overload where the average load is carried with a much shorter cutoff as, for instance, in the case of rolling-mill work.

When the valves are set for the latest possible cutoff the steam valves are given but little lap, the exhaust valves are open slightly when the wristplate is in mid-position, and the eccentric leads the crank little more than 90 degrees. This arrangement, while it is the best possible for the operation of the steam valves, giving a rapid opening movement, is not satisfactory for the exhaust valves as it makes for a late opening and the steam does not get out of the cylinder as early as it should.

This condition is remedied by the addition of a separate or exhaust eccentric allowing the adjustment of the exhaust valves independently. The separate exhaust eccentric was first applied to Corliss engines for the purpose of getting an early release with a late cutoff, but was not used to get an early compression, for at the time of its adoption it was customary to carry as little as possible, the exhaust valve closing just before the end of the stroke.

Later the independent exhaust eccentric was adapted to engines of the rolling-mill type or where an early opening of the exhaust, as in the case of a condensing engine, was necessary to get the benefit of the vacuum early in the stroke.

Setting the exhaust valves of the double-eccentric engine is not the complicated operation it at first appears, though many have balked at it without attempting to reason out the right course to pursue. The exhaust wristplate is secured at midtravel and the rods are adjusted to give the valves the same negative lap that would be given if there were but one eccentric on the engine. The piston is moved to the position in the cylinder where it is desired that compression shall begin, and the eccentric is turned on the shaft in the direction the engine is to run until the edge of the valve is on a line with the edge of the port. The eccentric is fastened and the piston is then moved to the other end of the cylinder to test the accuracy of the work.

In many cases, the exhaust eccentric is nearest the frame and is set before the other as a matter of convenience. But whether it is set first or last, it is not a task from which the engineer should shrink or feel the least hesitancy in attempting.

Know the Details

To successfully handle a repair job nothing is more important than a thorough knowledge of the causes which made the repair necessary. If a repair is to be made, a history of the previous conditions and an analysis of those conditions will, if intelligently applied, often prevent a recurrence of the need for the same kind of repair.

At the top of a vertical boiler the gasket under the steam-outlet pipe blew out and was replaced, only to fail again as the working pressure was approached. The operation was repeated twice, with the same result.

Discouraged by the continued failure and unable to account for it, the engineer sought the advice of the chief engineer of a nearby power plant, who had the reputation of having had few failures and of seldom erring in judgment in an emergency.

When he arrived he insisted upon having the whole story before looking at the job. He then examined the flange faces and tested them for accuracy. He examined the packing that was to be used and found that so far there was nothing that appeared to be out of the ordinary line. The flanges were true and came together fair; the packing was of good quality and should make a tight joint. He next turned his attention to the stud bolts around the hole in the boiler head. Upon trying the nuts he found that three of them would fit three of the four studs, that one would fit none of them, and that none of the nuts would fit on one particular stud. Here was the cause of the failure. In some way the threads on the one stud or in the one nut had been slightly deformed and in forcing the nut on the stud so much strength was expended that there was little left for producing pressure on the gasket at this point.

By means of a split die held in a patternmaker's clamp the stud was put in shape, and a tap run through the nut made that all right. Then the gasket was put in and the nuts screwed down solid.

As the temperature rose while getting up steam, the joint was "followed" by judiciously tightening the nuts, and when the working pressure was reached and the engine started everyone was satisfied that the repair was permanent, as it proved to be.

This incident illustrates two points in power-plant operation: The necessity for a thorough knowledge of the details of the work to be done and the application of mechanical common sense, without which the most ordinary work is poorly done and usually unreliable.

"So Easy to Fool 'em"

Whether a central-station contract agent retains his job or not depends entirely upon how successful he is in securing contracts. Is it any wonder, then, that he puts much energy and all of the intelligence he has into his efforts to close down the isolated plant?

In some localities and under some conditions central-station service is actually cheaper than operating an isolated plant. It is our belief, however, that more isolated plants are closed down to the ultimate loss of the owner than otherwise, and, furthermore, that the bulk of the blame for this state of affairs rests largely with the isolated-plant engineer himself.

In order to combat the central station successfully, the isolated-plant engineer must put as much knowledge and energy into the contest as the other fellow does.

That the central-station agent realizes that he is wasting time in trying to get an alert and capable isolated-plant engineer's job away from him is demonstrated by a remark actually made by a central-station solicitor after calling on the engineer of the plant in an office building of moderate size to get data in regard to the work the plant was doing, in order that he might make an estimate to cover a proposal for central-station service. Discovering that the engineer had in hand accurate and complete figures on the cost of the power he was producing, the solicitor said: "If more engineers kept track of costs it wouldn't be so easy for us to fool 'em." Note the last five words: "so easy to *fool* 'em."

There is a valuable lesson for some of us in that remark. Perhaps a few isolated-plant engineers will get it and profit thereby.

Visionary schemes in power-plant practice may work out all right once in a while, but it is better to determine what may reasonably be expected of any proposed improvement before much money is spent.

Inquiries of General Interest

Questions are not answered unless accompanied by the name and address of the inquirer. This page is for you when stuck—use it

Bronze and Babbitt Pin Bearings

Why do some engines have bronze wristpin boxes and babbitted crank-pin boxes? B. P.

The crank pin turns entirely around in its box in a revolution, while the wristpin box simply vibrates through a few degrees. There is, therefore, much less friction developed in the crosshead bearing, and some designers feel that it is better to use a harder metal there.

Effect of Advanced Eccentric

Will a compound Corliss engine with a speed of 42 revolutions per minute race if the eccentric is advanced too far? What influence will the eccentric have on a Corliss engine more than making the valves act earlier? L. W.

Advancing the eccentric on a Corliss engine without altering the lap of the valves will cause earlier lead and exhaust-valve closure, which with a very light load might make the speed of the engine irregular but would not cause overspeed enough to be called racing.

Advantages of High Piston Speed

What are the advantages of high as compared with low piston speed? E. W. C.

High piston speed produces a correspondingly greater amount of power with the same mean effective pressure and enables one to use a smaller engine for the same work. The disadvantages are the difficulties of taking care of the greater momentum of the moving parts and of getting the steam, or other working fluid, in and out of the cylinder in the shorter time available.

Moving Eccentric in Setting Valve

Is it always necessary to loosen the eccentric on the shaft when setting Corliss engine valves? F. B. C.

It may or may not be necessary in setting Corliss engine valves to move the eccentric. Give the valves the proper lap, with the wristplate at the middle of its travel without any reference to the position of the crank or eccentric. Then turn the engine to the center. If the lead is correct, the eccentric need not be moved.

Constant Potential at All Loads

It is desired to preserve a constant electromotive force at all loads at a point outside of the station, what kind of a dynamo should be installed at the station? Explain the action of this dynamo. C. E. N.

A compound-wound dynamo will maintain approximately constant potential at any given point in the circuit by proper adjustment of the compounding. If the system is direct current and the potential does not need to be rigidly constant, this type of machine is preferable. Its regulation is effected by means of an extra field winding in series with the armature. As the load increases, the current in this winding increases, and that strengthens the field magnet of the machine and thereby increases the electromotive force generated in its armature winding sufficiently to make up the voltage drop in the armature and line and keep the potential practically constant at the stated point.

Heat Loss to Ashpit

If the analysis of some bituminous slack having a heat value of 12,500 B.t.u. per pound is, ash, 10 per cent.; volatile matter, 37 per cent.; sulphur, 2 per cent., and if the refuse in the ashpit has a heat value of 3750 B.t.u. per pound and an analysis showing, ash, 75 per cent.; volatile matter, 5 per cent., and sulphur, 0.5 per cent., what is the percentage of heat lost to the ashpit? C. M. R.

One pound of coal, if the combustible which it contained were completely burned, would yield 0.1 pound of ash having no heat value.

According to the data given, however, all of the combustible in a pound of coal is not completely burned, and some fraction of a pound is rejected as ash.

The material rejected as ash must contain the 0.1 pound of true ash as found by the analysis of the coal itself, and enough fixed carbon and volatile matter to yield 3750 B.t.u. per whole pound of the assumed ash. As, by analysis, 75 per cent. of this assumed ash is true ash, and as it has been shown that each pound of coal contains 0.1 pound of true ash, the entire amount of assumed ash must weigh

$$\frac{0.1}{75} \times 100 = 0.133 \textit{ pound}$$

If a whole pound of this assumed ash has a heat value of 3750 B.t.u., then 0.133 pound has a heat value of

$$3750 \times 0.133 = 500 \textit{ B.t.u.}$$

Then, for each pound of coal fired 500 B.t.u. are lost, due to the unburned combustible in the assumed ash found in the ashpit. This loss expressed in percentage is

$$\frac{500}{12{,}500} = 0.04 = 4 \textit{ per cent.}$$

Double Eccentric Valve Setting

I would like very much to have instructions for setting the valves and eccentrics on a double eccentric Corliss engine. D. E. C.

With the wristplate in the middle of its travel, give the valves the proper lap. With the engine on the center turn the steam eccentric until the steam valves have the proper lead; 1/32 inch for an 18-inch to ¼ inch for a 72-inch cylinder.

Place the piston at that point in the travel where it is desired that compression shall begin, and turn the exhaust eccentric ahead until the exhaust-valve edge is on a line with the edge of the port.

Power to Draw Load up a Grade

A grade 1000 feet long has a rise of 50 feet. What horsepower is required to draw a load of 200,000 pounds to the top in one minute, assuming the friction to be 2 per cent.? D. L. G.

Two per cent. of 200,000 is 4000 which added to the load gives 204,000 pounds to be raised 50 feet. To lift 204,000 pounds 50 feet requires the expenditure of

$$204{,}000 \times 50 = 10{,}200{,}000 \textit{ foot-pounds.}$$

A horsepower is equivalent to 33,000 foot-pounds of work per minute. If the 10,200,000 pounds of work is done in one minute, it will take

$$\frac{10{,}200{,}000}{33{,}000} = 309.09 \textit{ horsepower}$$

Refrigeration Department

Principles and operation of ice making and refrigerating plant and machinery

Ammonia Absorption Refrigerating System

By Fred Ophüls

Of all the plants usually placed in charge of stationary engineers, those that are equipped with the ammonia-absorption refrigerating machines have given the most concern. There are comparatively few engineers who can successfully handle this system, not because the machines and apparatus necessary for its proper operation are particularly delicate, or have to perform functions unlike those generally performed by machinery in other kinds of power plants, but because the mode of operation of this system is very different from that of the usual run of power plants, both chemical and mechanical changes being involved. While there can be found hundreds of engineers able to handle the ammonia-compression system, very few are competent to operate the ammonia-absorption system, merely because the latter is not as well understood.

It is the purpose of this series of articles to present to the operating engineer a simple explanation of the mode of operation of the ammonia-absorption refrigerating machines, and to show later, by actual results obtained from a modern installation of this kind, how the functions of the various machines and apparatus making up this system are related to each other. Besides this, a discussion will be given bearing on the use of both the compression and absorption systems of refrigeration for purposes where the latter has heretofore been considered best adapted.

The function of a refrigerating system is to remove heat and maintain temperatures lower than those of the atmosphere; whether it be to freeze water, cool rooms for preserving in them perishable goods, or for whatever other purpose. Heat is not a tangible substance like water; that is, it cannot be removed directly from one place to the other, but it must be absorbed by some medium which can then be removed from the refrigerator. The medium which is used to absorb the heat is called "the refrigerating medium," and as heat can only be made to flow from a body at a higher temperature to another at a lower temperature, it is necessary that the temperature of the refrigerating medium be lower than that at which ice will form, or be lower than the temperature to which it is desired to cool the perishable goods and that of the room in which they are to be stored. The refrigerating medium simply acts as a sponge to absorb the heat, after which it is removed and subjected to an operation by which the heat it has absorbed can be discarded.

The choice of a suitable refrigerating medium was a difficult one; but after many laborious experiments several substances were found suitable for this purpose. Among these anhydrous ammonia is the one most commonly used, and among the reasons for its choice are that it can be readily manufactured as a byproduct of another manufacturing process and at a price which is not prohibitive.

Anhydrous ammonia at ordinary temperatures and under atmospheric pressure exists in the gaseous form, but when it is subjected to a certain higher pressure, it can be liquefied when cooled to ordinary atmospheric temperatures. If, from the liquid so obtained part of the pressure is removed, it will again vaporize if sufficient heat be supplied to it and the temperature at which it will vaporize will be that at which the liquid boils at the lower pressure.

The property which all liquefiable gases or vapors have in common is that when in the liquid form their boiling point increases with the pressure under which they are maintained. A familiar example of this property can be found in the formation of steam from water. The latter, when heated under atmospheric pressure, boils at 212 degrees Fahrenheit. When heated in a closed vessel, however, and only part of the steam generated is allowed to escape, the pressure in the vessel is raised, and the boiling point will be raised; that is, the temperature of the water is raised above 212 degrees Fahrenheit before boiling will begin. For instance, at a pressure of 100 pounds per square inch gage, water will boil at about 338 degrees Fahrenheit.

Liquid anhydrous ammonia, however, boils at very much lower temperatures than water under the same pressures. Under atmospheric pressure liquid anhydrous ammonia boils at about — 28 degrees Fahrenheit, and under a pressure of 100 pounds per square inch gage it boils at 63 degrees Fahrenheit.

Furthermore, when a liquid is boiled and changes its state from a liquid to a vapor, it absorbs a large amount of heat called "latent heat," and the latent heat of liquid anhydrous ammonia at low temperatures is made use of in refrigerating apparatus to absorb heat in order to produce cold.

Liquid anhydrous ammonia is commercially sold in iron drums in which it is contained under a pressure varying between 120 and 200 pounds gage, the pressure in the drum depending on the temperature of the liquid in it. This liquid is charged into the refrigerating system and brought into contact with the substance to be cooled or frozen under a pressure sufficiently low that its boiling point is lower than the temperature at which the substance is to be maintained.

The liquid or refrigerating medium will be vaporized by the heat flowing into it from the substance and the vapor formed could then be discharged into the open air. Such a refrigerating system would not require complicated machinery for its operation, but would be impractical and very expensive to use on account of the large amount of anhydrous ammonia that would have to be purchased. Furthermore, ammonia vapors will cause death when inhaled in large quantities, and therefore cannot be discharged into the open air. For these and other sufficient reasons it was found necessary to devise some means by which the ammonia vapor could be deprived again of the heat it had absorbed in the refrigerator and be reliquefied.

TABLE 1. SOME PROPERTIES OF LIQUID ANHYDROUS AMMONIA

1 Pressure on liquid in pounds per square inch gage.	2 Corresponding boiling points of liquid, in degrees Fahrenheit
2.35	— 23
2.80	— 22
5.24	— 17
6.29	— 15
136.75	+ 79
142.08	+ 81
144.80	+ 82
147.56	+ 83

Table 1 gives some properties of liquid anhydrous ammonia. The figures in the first column are the gage pres-

sures in pounds per square inch under which the liquid will boil at the temperatures given in the second column. These figures indicate the method that must be pursued to liquefy the ammonia vapor and abstract from it the heat absorbed in the refrigerator.

For instance, if the liquid anhydrous ammonia is allowed to flow from the iron drums in which it was bought, into the cooling or freezing coils under a pressure of 2.35 pounds, it will absorb heat and boil at a temperature of — 23 degrees Fahrenheit. The vapor formed must be drawn from the coils in order to maintain the desired low pressure in them; it can then be compressed to a suitable pressure, say, 136.75 pounds per square inch gage. The table shows that at this higher pressure liquid anhydrous ammonia boils at 79 degrees Fahrenheit. Provided there is cooling water available at from 54 to 70 degrees Fahrenheit, the compressed vapor can be cooled to 79 degrees and liquefied at this temperature, the point of liquefication for any fluid being the same as its boiling point under the same pressure. Having reliquefied the ammonia vapor the liquid formed can be used again for cooling and freezing purposes, the cooling water carrying off the heat absorbed in the refrigerator.

TABLE 2. SOLUBILITY OF GASES AND VAPORS IN WATER AT ATMOSPHERIC PRESSURE AND VARIOUS TEMPERATURES

Volumes of gas dissolved by one volume of water at.....	Degrees Fahrenheit				
	32	39.2	50	60	70
Ammonia.....	1049.0	941.9	812.8	727.2	654.0
Sulphur dioxide..	78.8	69.8	56.6	47.3	39.4
Carbon dioxide...	1.8	1.5	1.2	1.0	0.9

There are various ways of drawing the ammonia vapors from the cooling coils and compressing them to a higher pressure. In the absorption machine these two steps are accomplished by the use of water.

The figures in Table 2 show that water will absorb ammonia in greater volumes than it will either sulphur or carbon dioxide. They further show that the volume of each gas or vapor absorbed decreases as the temperature increases, and if a saturated solution at 32 degrees is heated to, say, 70 degrees, part of the gas or vapor will be again given off from the solution.

Therefore, the ammonia vapor can be drawn from the refrigerator coils by connecting them with a vessel, called the absorber, containing cold water or a weak solution of ammonia in water, called weak ammonia liquor. The weak liquor will absorb the ammonia vapors readily until a saturated solution is obtained at the temperature and pressure of the absorber when the absorption stops. The saturated solution or strong liquor is then pumped from the absorber and discharged into a tank, called the generator, in which a pressure at least equal to that required for liquefying the ammonia vapors is maintained. In the generator the strong liquor is heated and part of the ammonia is driven off and discharged into a vessel called the ammonia condenser, in which the ammonia vapor is liquefied by the action of cooling water sprayed over or circulated through it.

The removal and discarding of the heat can be likened to the removal of water from a basin without a drain, to a basin at a higher level but with a drain, by means of a sponge. The dry sponge, brought into contact with the water in the lower basin, will absorb part of it, similar to the flow of heat from the refrigerator into the refrigerating medium. The saturated sponge is then lifted to the higher basin and is compressed so that the water is discharged from it and can run to waste. The sponge, having been compressed and the water discharged from it, can be brought to the lower basin again and is ready to absorb more water. The refrigerating medium, being deprived of the heat it had absorbed and reliquefied, can be reduced in pressure so that it can absorb more heat. In the case of the water, the level to which it is raised is measured in a certain number of feet, whereas in the case of the heat the level to which it is raised is measured in so many degrees of temperature.

CORRESPONDENCE

Clear Ice without Reboiling

A short time ago I was conducted through a can-ice plant and was surprised to find that there were no steam coils in the skimmer and reboiler. I told the chief engineer that he surely could not expect to produce crystal ice without reboiling the condensed water, but he replied that they have been doing this all along, although it was violating the primary principle of the can-ice system. He admitted that during the recent hot weather, while the plant was being pushed beyond its capacity, with the temperature of the brine tank at about 10 degrees Fahrenheit, the ice was slightly cloudy, but still transparant enough to be marketable without the slightest trouble. At other times, however, when it is possible to keep the temperature of the brine tank at about 16 degrees Fahrenheit, giving the ice 50 hours or more to freeze, it is as clear as any.

I asked him if there was a story to tell in connection with the removal of the steam coils from the reboiler. He said there was, and related the following:

When the plant was erected, the builders estimated that there would be a shortage of condensed water amounting to 15 or 20 per cent. To overcome this they connected a water pipe to the exhaust reheater, thinking that by mingling the water thus admitted with the exhaust and passing it through the condenser and reboiler, the necessity of using live steam to make up for the shortage would be eliminated. But the results were disappointing. The ice had a very muddy appearance with a large red core to it. At first they tried to overcome this by employing various filtering devices, but without avail; the color of the ice remained the same. Then the water from the exhaust reheater was shut off and while this improved conditions to a certain extent, the color of the ice was still muddy and red enough to be unmarketable. Then came some more filtering devices, but all of them failed. Finally in desperation they shut off the steam on the reboiler. The result was clear ice and they have not had trouble since.

Upon further inquiry, however, I found that the water supplied to the plant contained considerable iron and other ingredients which were responsible for the muddy and red appearance of the ice, but which condition was overcome by cutting out the reboiler entirely.

VICTOR BONN.

New York City.

Protecting Compressor

In the city of Boston a few months ago a chief engineer in one of the breweries was killed by the blowing up of a compressor. He had been chief engineer for the brewery for 25 years and would never allow a man to start the compressor for fear he would forgot to open the discharge valve; but careful as he was, he finally got caught himself.

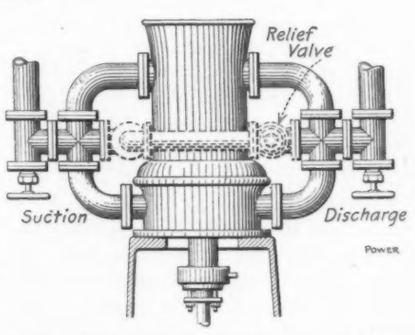

FIG. 1. SAFETY VALVE BETWEEN SUCTION AND DISCHARGE

Fig. 1 gives my idea of a remedy. The full lines show the original connections of the compressor and the dotted lines the modifications. In the piping between the suction and discharge valve a safety valve is connected and set to a desired pressure, presumably about 300 or 350 pounds. When the pressure builds up too high the safety valve will let go and

discharge the ammonia into the suction side of the compressor.

Fig. 2 is a sketch of a wrinkle that we use in our plant to prevent starting up the compressor with the discharge valve closed. The rule is not to start a machine unless the telltale is hanging on the stem of the discharge valve, which it can only do when it is open. If it cannot be put on it means that the valve is closed.

It consists of a flat piece of tin the upper part of which is so twisted that

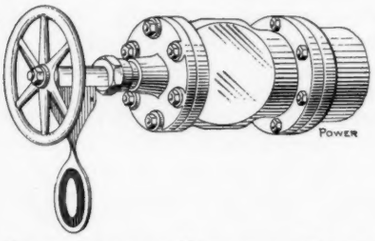

FIG. 2. TELLTALE HANGING ON VALVE STEM

in hanging it on the valve stem the body of the tin will face the engineer. The telltale should be painted white and bright red so as to attract attention.

EDGAR G. SCHINDLER.

Roxbury, Mass.

Air in Ice Water System

The milky appearance of ice about which Charles J. Johnson wrote in the issue of June 13, is undoubtedly caused by air and impurities in the circulating water. It may be similar to Lake Erie water. In Cleveland, O., for instance, some of the city water is pumped through a 9-foot tube from an intake five miles out in the lake. There the pumping is not responsible for the milky condition, because water taken from the lake direct has the same appearance. If left standing for about 15 seconds it becomes quite clear. I doubt very much if the remedies proposed—an air trap on the supply line to the pump, or a pipe direct down from the supply tank on the roof, or both—will bring the desired relief.

A certain amount of air is always introduced with the fresh water, but the greater part is admitted whenever the piping is drained. The stale water throughout the system ought to be completely run to waste at least once a week, or oftener if necessary, but to do so requires air to be admitted by a vent for the purpose of breaking the vacuum. On Mr. Johnson's sketch no vent can be detected, which would imply that he does not change the water. Of course, the stale water becomes mixed with the remaining cold water and ultimately finds its way to the faucets, the issuing liquid being milky in appearance. A cloth disk filter (made by the International Filter Company, of Chicago) in the fresh-supply line, cleaned often enough, and a frequent draining of the system would improve the appearance and wholesomeness of the drinking water.

After the system has been drained it is full of air. If now a vent pipe, not smaller than 1 inch, is connected to the highest point of the circulating pipes, the new water can force the air out ahead of it. To prevent the water from escaping, the vent pipe must extend up to the highest level, in fact a few feet more; and preferably be protected against rain, dirt, heat and frost. A ½-inch valve on top of the closed cool-tank, to help let the air out, would also be an advantage.

A vent having been provided, the expulsion of air from the system will further be favored by simply discharging the cold water through the present 1½-inch return pipe of the pump, in this way circulating in a direction opposite to that now used. In other words, feed the water upward through the eighteen ¾-inch risers of the building, this being the direction in which the air moves naturally. This method ought to be so effective that the air will easily escape and thus make the installation of a cumbersome tank and other changes unnecessary.

The centrifugal pump used at present is, in Mr. Ophüls' opinion (June 27 issue), the chief reason for the milky appearance of the water; it being supposed that this pump divides the air so finely that it would not rise from the water unless a large disengaging surface is provided. It may be that the churning action of this pump does contribute to the evil more than a slow-speed piston pump would, but I believe in making this expensive change only after everything else has been tried. Triplex plunger pumps are frequently used in connection with unbalanced circulating systems, being better adapted for high heads than common centrifugal pumps, but they are more expensive and noisy.

Perhaps the pump is being driven faster than necessary. The actual consumption is certainly not in excess of 4 gallons per minute. If, to prevent a greater rise in temperature and to eliminate excessive waste of the water first drawn from the faucet, six times as much water is circulated, this would mean 24 gallons per minute as the flow capacity of the system, at which rate the friction per 100 feet of 1½-inch pipe would be only 2.6 pounds. The water leaving the cooling tank at, say, 43 degrees Fahrenheit must not come back colder than 53 degrees, which temperature physicians prescribe as being proper for quenching thirst. If the water returns at, say, 50 degrees, the speed of the pump can be reduced.

For the maintaining of uniform temperatures it is better to depend on regulating the refrigeration produced, than to simply alter the rate of flow by means of a bypass around the pump. Also, the regulating valves at the top and the bottom of the risers should be left wide open. If, owing to the greater pressure prevailing, the water issues with too much force from the faucets on the lower floors, their effective opening can be plugged down to 1/16 inch diameter if necessary. Why there should be ¾-inch globe valves used on the ¼-inch outlet pipes, as shown in the sketch on page 934, is not apparent.

When the foregoing has been tried, and no satisfactory results have been obtained, recourse may be had to the large tank recommended by Mr. Ophüls, although many plants are operating satisfactorily without it. The connection of the 2-inch horizontal run at the top with the 2-inch riser will have to be cut off. For upward circulation through the eighteen ¾-inch pipes the 2-inch riser can then be continued up to the bottom of the feed tank, and a 2-inch pipe carried direct from the horizontal run to the tank, entering just below the water level, preferably at a tangent. For downward circulation, the 2-inch riser would have to be continued to the top inlet of the tank, and the outlet connected with the 2-inch horizontal run or header.

In neither case does the use of the open tank permit the fresh supply to be taken into the system at the basement as at present, because of lack of suitable control. The cheapest way is to convey the water direct from the roof tank through a ¾-inch pipe to the balancing tank, the outlet being fitted with a float valve to keep the water level constant. Under the feeble pressure available up there, it will be difficult to use an ordinary filter successfully. A separate feed line from the basement to the balancing tank on the top floor would permit the use of a pressure filter in the basement.

This arrangement will still act as a balanced system, except that the head will be increased by the elevation of the de-aerating balancing tank, but with no appreciable effect on the power required by the pump. As to the size of this galvanized tank, it should not be more than 3 feet in diameter and 3 feet high, which would be big enough to easily hold 120 gallons, the equivalent of five minutes' pumping. The bottom and sides of the tank should be well insulated, and the open top protected, in addition to providing an overflow pipe and drain.

CHARLES H. HERTER.

New York City.

By the control and development of its water powers, Tennessee hopes to largely increase its revenue and give employment to an additional million people.

New Power House Equipment

What the inventor and the manufacturer are doing to save time and money in the engine room and power house. Engine room news

Toltz Superheater

In construction this superheater consists of seamless drawn-steel tubes expanded into steel headers. Fig. 1 shows a general form designed for installation in a horizontal type of water-tube boiler. The headers are placed alongside the boiler drums, away from the heat of the furnace, and the tubes extend down into the setting, across and under the drums in the first gas pass, where they are subjected to the heat.

The tubes are round at the ends so that they may be properly expanded into the headers and at the bends. They may, therefore, expand in the heat of the gases without injury or change of shape. In the run, the tubes are flattened so as to get the steam into a thin sheet, thus thoroughly superheating it. It is claimed that this construction enables the heat to easily reach the body of the steam and distribute the temperature uniformly throughout its mass.

Fig. 2 shows the Toltz superheater as installed in connection with a horizontal, return-tubular boiler. The headers in this case are above the combustion chamber, where they are not subjected to the heat of the gases. The superheating elements consist of a U-section of seamless drawn tubes. Application of this superheater to other types of boilers is made by employing either horizontal or vertical superheating elements, always retaining the feature of outside headers.

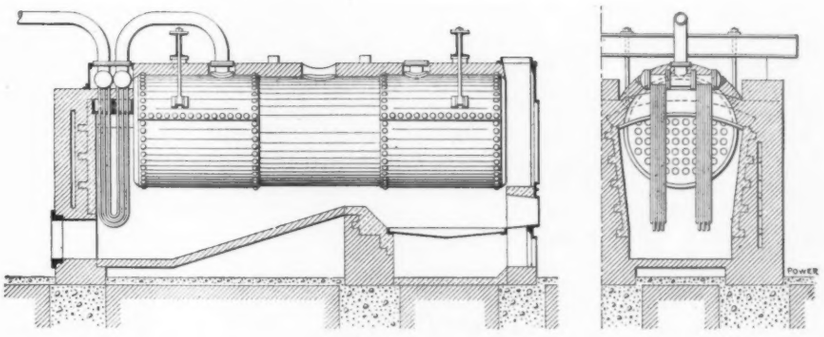

FIG. 2. SUPERHEATER INSTALLED IN RETURN-TUBULAR BOILER

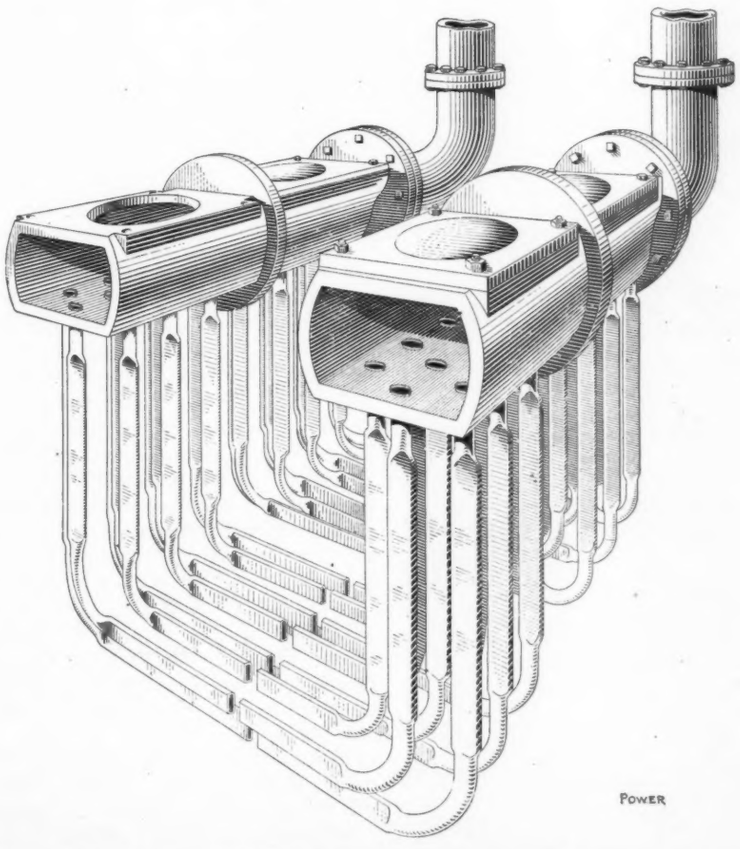

FIG. 1. TOLTZ SUPERHEATER DESIGNED FOR HORIZONTAL WATER-TUBE BOILER

The Toltz superheater prevents the superheat from becoming too high by the use of a bypass controlled by a thermostatic valve so that saturated steam may be admitted to the superheater. It is claimed that the temperature of the superheated steam can be maintained within 8 per cent. of the maximum superheat for which the apparatus is set.

The Toltz superheater is being placed on the market by the Power Improvement Company, 510 Enterprise building, Milwaukee, Wis.

Class "P B" Duplex Power Driven Air Compressor

This compressor is of the familiar duplex type with the air cylinder coupled to the frame and a central driving wheel. It is of the latest design in power-driven air compressors, and is of inclosed, dustproof construction with automatic flood lubrication for the main bearings, crank pins and crossheads. These compressors also have increased wearing surfaces, large valve areas and greater intercooler surface.

The principal new features are the water separator and the clearance controller.

Details of the water separator are shown in Fig. 1. It consists of a large water separator or moisture trap which

is placed on the discharge pipe of the intercooler, through which all air after cooling must pass. It is made with two concentric cylinders, with two overlapping lips, between which the air passes. Entrained moisture is caught on the surface of the inner cylinder and projecting lips and drains to the chamber in the bottom of the separator, from which it is removed through a drain cock. This device results in the delivery of practically dry air to the high-pressure cylinder.

The automatic clearance controller, shown in Fig. 2, is a device for economically regulating the capacity of the compressors by varying the amount of clearance. It consists of a number of clearance pockets which are thrown automatically into communication with the ends of each air cylinder in proper succession, this process being controlled by a predetermined variation in the receiver pressure. Regulation is obtained in five stages, namely, full load, three-quarter load, half load, quarter load and no load.

The operation of this system of regulation is as follows: With the compressor operating at partial capacity, a portion of the air is compressed into an added clearance space instead of passing through the discharge valves. This air expands on the return stroke, giving up its stored energy to the piston. The inlet valves remain closed until the cylinder pressure equals the intake pressure, and then open automatically by a slight difference of pressure; free air is admitted to the cylinder for the remainder of the return stroke. The inlet capacity of the compressor is thus reduced without reducing the intake pressure.

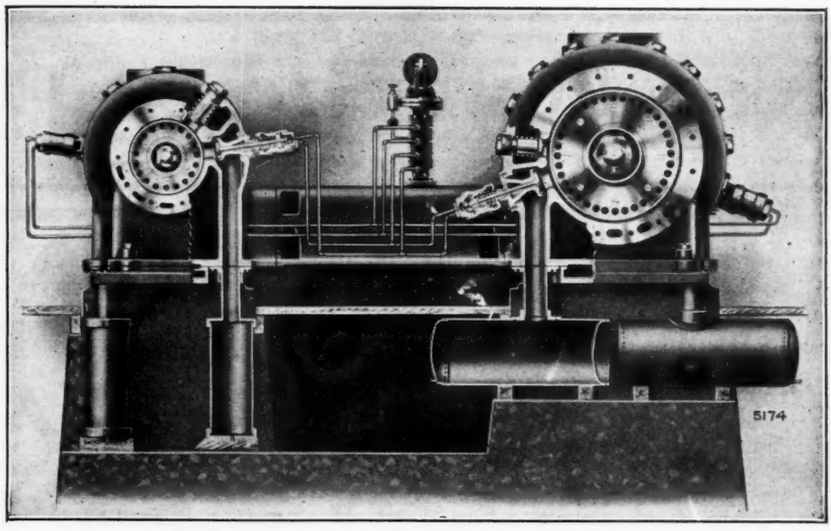

FIG. 2. AUTOMATIC CLEARANCE CONTROLLER

On a two-stage compressor, clearance space in the proper proportion is added simultaneously to both high- and low-pressure cylinders, thus maintaining a constant ratio of compression throughout the entire load range and obtaining the highest compression efficiency. The reduction in power secured with this method of control is practically in direct proportion to the reduction of load. This regulator is simple in construction and entirely automatic in operation.

The compressors on which these devices are used are made by the Ingersoll-Rand Company, 11 Broadway, New York City.

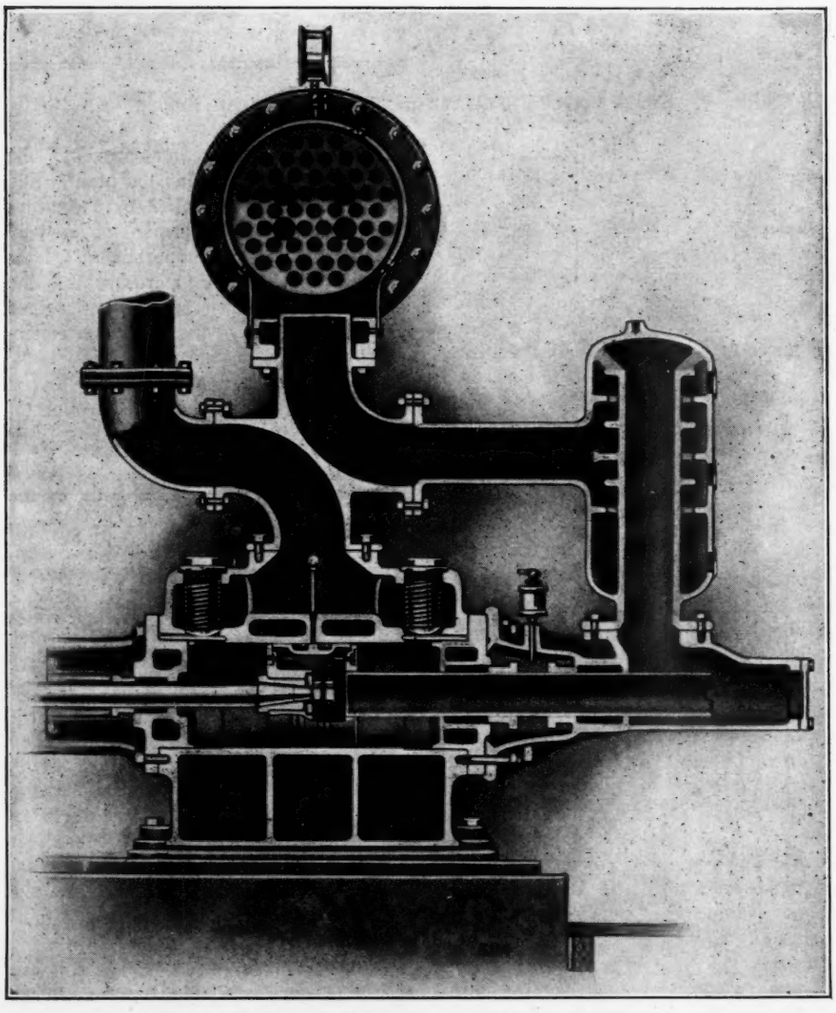

FIG. 1. SECTIONAL VIEW OF THE WATER SEPARATOR

Peat Society Convention

The annual convention of the American Peat Society will be held this year at Kalamazoo, Mich., on September 21, 22 and 23. The arrangements are in the hands of the executive committee which has laid out a large and attractive program. Among the papers to be read are the following: "The Peat Gas Producer of the Department of Mines, Canada," by B. F. Haanel; "Latest Development in Gas Producers," Professor Fernald; "Peat Dredging," Messrs. Bulask and Garnett; "Powdered Peat for Power," Doctor MacWilliam; "Peat Excavators," L. B. Lincoln; "Recent Developments of Peat as a Power Factor," Doctor Mighill; "Drainage of Peat Deposits," Doctor Pratt; "The Canadian Government Peat Fuel Plant," A. Anrep, Jr., and a paper by Dr. N. Caro, the subject of which will be announced later. It is expected that Gifford Pinchot will be present and deliver an address.

For particulars inquiry should be made to Julius Bordollo, Kingsbridge, New York City.

Universal Craftsmen's Convention

The ninth annual convention of the Universal Craftsmen Council of Engineers was held in Philadelphia, Penn., August 8 to 11. The Majestic hotel was the headquarters, and the business sessions of the convention were held behind closed doors in the main banquet hall. The Parisienne café of the hotel was tastefully arranged by the supplymen for their exhibit.

On Monday evening at seven o'clock, Charles A. Hopper, chairman of the committee of supplymen, introduced Grand Worthy Chief John Cope, who formally opened the exhibit in an appropriate speech.

On Tuesday morning at ten o'clock the delegates and guests assembled in the main hall of the Majestic hotel for the preliminary proceedings of the convention.

Thomas O. Organ, chairman of the convention committee, introduced the Rev. Charles H. Bond, who offered the invocation.

The address of welcome was made by Samuel W. Wray, private secretary to the Grand Master of Masons of Pennsylvania. He was responded to by Grand Worthy Chief John Cope.

Addresses were also made by the Hon. Robert Bringhurst, ex-city treasurer, and Past Grand Chiefs W. S. Cadwell and Robert J. Ingleson.

The features of entertainment included visits to Independence hall, Masonic Temple, Fairmont park and Willow grove.

On Wednesday evening an entertainment was given under the auspices of the supplymen, comprising the following enjoyable numbers: Joe McKenna, popular songs; Johnny Forsman, songs and dances; Frank Corbett, Consolidated Safety Valve Company, tenor solos; Jim Devins, Peerless Rubber Manufacturing Company, monologue; Monroe Silver, parodies; Billy Murray, Jenkins Brothers, uptodate ditties; Jack Armour, of POWER, songs and stories. Frank Martin, of Jenkins Brothers, was the master of ceremonies.

After the performance the delegates were entertained by the supplymen in the main dining room.

At the closing session on Thursday afternoon the following grand officers were elected:

John Cope, past worthy chief, Cleveland, O.; Thomas H. Jones, worthy chief, Washington, D. C.; James U. Bunce, assistant worthy chief, Buffalo, N. Y.; Henry C. Senn, secretary, Batavia, N. Y.; Nelson J. Burdick, treasurer, Chicago, Ill.; P. H. Early, chaplain, Milwaukee, Wis.; William Armstrong, warden, New York, N. Y.; William Wyklen, guard, Chicago, Ill. Charles Siegrist, Cleveland, O.; H. E. Terry, Toronto, Ont., and Henry Klug, Tacoma, Wash., were chosen as trustees.

It was voted to hold the next annual meeting in St. Louis, Mo.

The following firms had exhibits: V. D. Anderson & Co., John R. Livezey, POWER, Jenkins Brothers, Dearborn Drug and Chemical Works, Quaker City Rubber Company, Greene, Tweed & Co., Lunkenheimer Company, W. B. McVicker Company, the C. E. Squires Company, the Elliott Company, the Anchor Packing Company, American Steam Pump Company, France Packing Company, Standard Manufacturing and Supply Company, Keystone Lubricating Company, the Garlock Packing Company, the Cyrus Borgner Company, Under-Feed Stoker Company of America, A. B. Botfield & Co., the Lagonda Manufacturing Company, Watson & McDaniel Company, McLeod & Henry Company, *Southern Engineer*, O. F. Zurn Company, E. J. Rooksby Company.

UNIVERSAL CRAFTSMEN AT PHILADELPHIA

SOCIETY NOTES

On August 17, J. N. Mulder, of Amsterdam, Holland, presented an interesting paper on "Some Types of Internal Combustion and Steam Engines" before the American Society of Engineer Draftsmen at the Engineering Societies building, New York City. On June 18, 1911, this society had been in existence for one year, and now has a large membership, extending over the entire country. To become a member a man must pass rigid requirements which certify to his competency as an engineer draftsman, and this feature is attracting the attention of employers who have come to look upon the society as a medium through which to secure men whom they can depend upon. A plan has been inaugurated whereby those, who through any good reason are not in a position to join as a member, may become associated with the organization for a limited time as an affiliate member. An affiliate does not enjoy the same privileges as a member, and is not entitled to vote at the meetings.

PERSONAL

Harry H. Pratt has severed his connections with the Du Bois Iron Works, Du Bois, Penn., having for the last four years been manager of the firm's Buffalo office, and has entered into business for himself. Mr. Pratt will be pleased to hear from manufacturers who desire representation in western New York.

Moments with the Ad. Editor

A department for subscribers edited by the advertising service department of Power

RALPH B. PHILLIPS is the treasurer and general manager of the American Steam Gauge and Valve Manufacturing Company.

He has accomplished things since he undertook the management of that concern which are noteworthy.

Mr. Phillips has always been a great *believer* in advertising. In other words he has great faith in it—and because of this and his judgment in mediums and follow-up he has made it pay.

He takes the broad view that to make advertising pay he must get an initial distribution of his goods through advertising and the repeat orders will take care of the selling expense.

So, of course, the first requisite is reliable products, and the second a selling organization of good men and advertising that is advertising.

Now, Mr. Phillips is going even farther, and occasionally devoting his space to an educational campaign to show and prove that engineers who are ambitious to get above the level will take the initiative and "put things" up to headquarters.

Here is what he has written us about it, and because there is sound sense in the doctrine we print it here.

Ad. Editor POWER,
New York.

Dear Sir:-

I personally believe it would be very advantageous for your advertisers as a whole if more of the full page advertisements occasionally contained copy similar to some which we have recently prepared showing the need for the engineer to go to headquarters and ask for the necessary power plant devices to run his engine room properly.

If quite a number of your full page advertisers do this, I am sure that the result will be generally beneficial to both readers and advertisers, and a concerted effort on the part of the advertisers and the editorial staff to show the engineer the necessity for doing this will certainly benefit every one. I hope you will find it advisable to take this matter up with some of your advertisers for whom you are doing work, and you can be assured of our hearty co-operation at all times. How can the advertiser expect to benefit unless he first shows the purchaser a way to benefit himself? Yours very truly,

AMERICAN STEAM GAUGE & VALVE MFG. CO.,
Ralph B. Phillips,
Treasurer and Gen. Mgr.

You may remember the story of the engineer who knew a lot about power plant engineering practice. He was a careful reader of the reading columns and advertising pages of his paper. He kept catalog files and interesting information and figures on plant equipment.

That was his trouble—he *kept* them.

One day the manager said to him: "Here's something new that looks pretty good to me, what do you know about it?"

"Why I know a lot about it," replied the engineer. "Only last night I was telling my wife how we could make good use of that here."

"Telling your wife!" exclaimed Mr. Manager. "What in blazes has she got to do with it? She doesn't run this plant. Why don't you come to me? I don't want to run a back-number plant and I'm depending on you as the power specialist to keep me informed."

The engineer went back to the engine-room with a new idea. He sat on it long enough to hatch out something that's been with him ever since—to his everlasting benefit. He has learned that knowledge without *action* is like a motor boat without gasolene—you don't get there.

He has also learned that he can suggest things to the management without being accused of "butting in."

Likewise he's gained a new respect for his own job.

When a man gets in *that* position he has so lived that he can look anybody in the eyes and tell him to "go to."